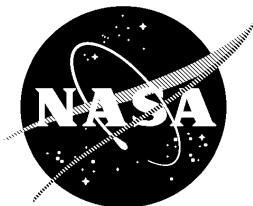


Earth Orbiter 1 (EO-1) Hyperion Interface Control Document



National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

Earth Orbiter-1 (EO-1) Hyperion Interface Control Document

Goddard Space Flight Center
Greenbelt, Maryland

Change Information Page

List of Effective Pages			
Page Number	Issue	Page Number	Issue
Title page	Baseline	11-1	Baseline
iii through xi	Baseline	12-1	IRN 001
1-1	Baseline	12-2 through 12-3	Baseline
1-2	IRN 001	12-4	IRN 001
1-3	Baseline	12-5 through 12-8	Baseline
2-1 through 2-3	Baseline	13-1	Baseline
3-1	Baseline	14-1	Baseline
3-2 through 3-3	IRN 001	14-2	IRN 001
3-4	Baseline	14-3	Baseline
3-5	IRN 001	15-1 through 15-2	Baseline
4-1 through 4-4	IRN 001	A-1	Baseline
5-1	Baseline	A-2	IRN 001
5-2	IRN 001	A-3 through A-7	Baseline
5-3 through 5-4	Baseline	B-1 through B-6	Baseline
6-1 through 6-5	Baseline	B-7 through B-9	IRN 001
7-1 through 7-2	Baseline	B-10	Baseline
7-3	IRN 001	B-11	IRN 001
8-1 through 8-2	Baseline	C-1 through C-2	Baseline
9-1 through 9-3	Baseline	AB-1 through AB-3	Baseline
10-1	Baseline		
Revision	Description	Date	Approval
– IRN 001	Baseline EO-1CCR 0031	2/05/99	3/22/99 6/28/99

Contents

Section 1. Introduction

1.1	Scope	1-1
1.2	Applicability.....	1-1
1.3	Approval	1-1
1.4	Revisions.....	1-1
1.5	Applicable Documents	1-2
1.5.1	Drawings.....	1-2
1.5.2	Specifications.....	1-2
1.5.3	Documents	1-3

Section 2. Hyperion Instrument Overview

2.1	The Hyperion Mission.....	2-1
2.2	The Hyperion Mission Objectives.....	2-1
2.3	Instrument Description	2-1

Section 3. Physical Description

3.1	Overview of Physical Configuration.....	3-1
3.2	Hyperion Sensor Assembly Description.....	3-1
3.3	Hyperion Power and Control Electronics Assembly Description.....	3-2
3.4	Hyperion Cryocooler Control Electronics Assembly Description.....	3-4

Section 4. Mechanical Interface

4.1	Overview of the Mechanical Interface	4-1
4.2	Mechanical Interface Reference.....	4-1
4.3	Instrument Reference Coordinate Systems.....	4-1
4.4	Instrument Sizes	4-1
4.5	Instrument Field of View	4-1
4.6	Mass Properties	4-2
4.7	Center of Mass	4-2
4.8	Mounting, Drill Template, Alignment, and Access	4-2

4.8.1	Mounting	4-2
4.8.2	Drill Template.....	4-2
4.8.3	Alignment.....	4-3
4.8.3.1	HSA X-Axis Alignment.....	4-3
4.8.3.2	HSA Y-Axis Alignment.....	4-3
4.8.3.3	HSA Z-Axis Alignment	4-3
4.8.4	Access.....	4-3
4.9	Base-Plate Flatness.....	4-3
4.10	Aperture Cover Operation and Uncompensated Angular Momentum.....	4-4

Section 5. Electrical Interface

5.1	Overview of the Electrical Interface	5-1
5.2	Electrical Interface Harness	5-2
5.3	Power Control	5-3
5.3.1	Over-Current Protection	5-3
5.3.1.1	Over-Current Protection Requirements	5-3
5.3.1.2	In-Rush Current	5-3
5.4	Spacecraft Bus Voltages	5-3
5.5	Hyperion Power Consumption.....	5-3
5.6	Electrical Grounding and Shielding	5-4
5.7	Electrical Isolation.....	5-4

Section 6. Command and Telemetry

6.1	Command and Telemetry Overview	6-1
6.2	Discrete Command and Telemetry Interfaces.....	6-1
6.3	Power-Off Command Sequence Restriction.....	6-1
6.3.1	Power-Off Command Sequence	6-1
6.3.2	Loss of 1773 Time Code “Tone Message”.....	6-1
6.3.3	Safehold Command.....	6-2
6.4	1773 Command and Telemetry Data Bus.....	6-2
6.5	Command and Telemetry Packet Protocol	6-2
6.6	Telemetry Packet Format and Acquisition	6-3

6.6.1	Telemetry Packet Format	6-3
6.6.2	Telemetry Packet Acquisition.....	6-3
6.7	Command Packet Format and Distribution	6-3
6.7.1	Command Packet Format	6-3
6.7.2	Command Packet Distribution.....	6-4
6.8	Time Code Distribution	6-4
6.9	Reset Command Packet.....	6-4
6.10	Wraparound Data	6-5

Section 7. Image Data Interface

7.1	32-Cable RS-422 Image Data Interface.....	7-1
7.1.1	Image Data Ports.....	7-1
7.1.2	Image Data Interface Circuit, Connector and Pin Assignments	7-1
7.1.3	Image Data Timing	7-1
7.1.4	Image Data Header	7-2
7.1.5	Image Data Format	7-2
7.1.5.1	VNIR Image Data Format.....	7-2
7.1.5.2	SWIR Image Data Format.....	7-3

Section 8. Hyperion Pointing Allocation

8.1	Spacecraft Pointing Knowledge Budget.....	8-1
8.1.1	Spacecraft Position Knowledge	8-1
8.1.2	Spacecraft Attitude Knowledge	8-1
8.2	Hyperion-to-Spacecraft Pointing Error Allocation	8-1
8.2.1	Hyperion Alignment Cube to Spacecraft Attitude Vector Error Allocation	8-1
8.2.2	Hyperion Boresight to Alignment Cube Error Allocation	8-1
8.2.3	Hyperion Image Data Time Tag Error.....	8-1
8.3	Hyperion Boresight Error Budget.....	8-2

Section 9. Thermal Interface

9.1	Description.....	9-1
9.2	HSA Thermal Interface	9-1

9.2.1	HSA Heat Transfer by Conduction and Radiation	9-1
9.3	HEA and CEA Thermal Interface	9-2
9.3.1	HEA and CEA Heat Transfer by Conduction and Radiation	9-2
9.4	Surface Treatment and Restrictions	9-2
9.5	Thermal Model and Analysis	9-3

Section 10. Electromagnetic Compatibility

10.1	Electronics Discharge Control	10-1
------	-------------------------------------	------

Section 11. Potential Hazards

Section 12. Hyperion Test Interfaces

12.1	Design Requirements.....	12-1
12.1.1	Minimum Natural Frequencies	12-1
12.1.2	Design Environments	12-1
12.1.2.1	Limit Loads	12-1
12.1.2.2	Factor of Safety	12-2
12.2	Predelivery Test Requirements	12-2
12.2.1	General Test Requirements	12-2
12.2.2	Vibration Tests.....	12-3
12.2.2.1	Sinusoidal Vibration	12-3
12.2.2.2	Random Vibration	12-3
12.2.3	Thermal Cycles Tests at Ambient.....	12-6
12.2.4	Thermal Vacuum Tests	12-6
12.2.5	EMI/EMC Testing.....	12-6
12.2.6	Functional and Performance Testing	12-6
12.3	Hyperion Instrument Acceptance Test at GSFC.....	12-6
12.3.1	Instrument Acceptance Tests.....	12-6
12.3.2	Hyperion Instrument TestSet (HITS).....	12-7
12.4	Post-Spacecraft Installation Hyperion Instrument Tests	12-7
12.4.1	Post-Spacecraft Installation Functional Test	12-7
12.5	Operating Time	12-8

Section 13. Contamination and Cleanliness

13.1	As-Delivered Contamination Requirement	13-1
13.2	Storage and Transportation Environment.....	13-1
13.3	Integration and Test Facility Environment	13-1

Section 14. Spacecraft Integration and Launch Site Requirements

14.1	Hyperion Operating Constraints During Spacecraft Integration.....	14-1
14.2	Integration and Test Facilities Contamination Level	14-1
14.3	Ground Support Equipment	14-1
14.3.1	Mechanical Ground Support Equipment.....	14-1
14.3.2	Electrical Ground Support Equipment.....	14-2
14.4	Transportation, Handling, and Storage.....	14-2
14.4.1	Transportation Requirements	14-2
14.4.2	Handling Restrictions	14-2
14.4.3	Storage Requirements	14-2
14.5	Satellite Environmental Tests	14-2
14.6	Models for Satellite Environmental Test.....	14-2
14.7	Safety Documentation	14-3

Section 15. Operational Requirements

15.1	Hyperion Instrument Operational Modes	15-1
15.1.1	Off Mode	15-1
15.1.2	Idle Mode	15-1
15.1.3	Standby Mode.....	15-1
15.1.4	Imaging Mode.....	15-1
15.1.5	Survival Mode	15-1
15.1.6	Orbital Instrument Operation Sequence for Image Data.....	15-2
15.2	Spacecraft Operation Constraints.....	15-2
15.3	Health and Safety	15-2

Figures

2.3-1	EO-1 Spacecraft in Its Deployed Configuration.....	2-1
2.3-2a	Location of the Hyperion HSA, HEA, and CEA on the EO-1 Spacecraft.....	2-2
2.3-2b	Location of the Hyperion HSA, HEA, and CEA on the EO-1 Spacecraft.....	2-3
3.1-1	Hyperion Instrument Block Diagram.....	3-1
3.2-1	Hyperion Sensor Assembly	3-2
3.3-1	Hyperion Power and Control Electronics Assembly (HEA) Interface (Drawing 868649-1, Hyperion Electronics Assembly Interface Control Drawing)	3-3
3.4-1	Hyperion Cryocooler Control Electronics Assembly (CEA) Interface (Drawing 868652-1, Hyperion Cryocooler Interface Control Drawing)	3-5
5.1-1	Hyperion Spacecraft Electrical and Data Interface Diagram	5-1
5.2-1	Hyperion Cable Diagram.....	5-2
7.1.2-1	Example of Image Data Interface Transceiver Circuit.....	7-1
7.1.3-1	Hyperion Image Data Interface Bit Leveling	7-2
7.1.5.1-1	Hyperion VNIR Data Frame Timing	7-2
7.1.5.2-1	Hyperion SWIR Data Frame Timing	7-3
8.2.3-1	Hyperion Science Data “Time Tag” Timing	8-1
8.3-1	Hyperion Pointing Error Budget.....	8-2
12.3.1-1	Hyperion Instrument Acceptance Test Configuration	12-7
12.4.1-1	Hyperion Spacecraft Integration and Test Configuration	12-8

Tables

4.10-1	Hyperion Aperture Cover Operation Timing	4-4
5.3.1.1-1	Hyperion Over-Current Protection Requirements	5-3
5.5-1	Hyperion Instrument Power Consumption.....	5-3
6.5-1	Hyperion Spacecraft Bus Schedule.....	6-2
6.5-2	Hyperion Instrument Command and Telemetry Channel Definitions	6-3
6.8-1	Time Code Distribution Channel Definition	6-4
6.9-1	1773 Reset Command Channel Definition.....	6-4
9.2-1	Detailed HSA Thermal Design Characteristics	9-1
9.3.1-1	Detailed HEA and CEA Thermal Design Requirements	9-2

9.4-1	Hyperion Surface Treatment Characteristics (α , ϵ)	9-2
12.1.2.1-1a	Flight Limit Loads Factors for the HSA	12-1
12.1.2.1-1b	Flight Limit Loads Factors for the HEA and the CEA	12-1
12.2.1-1	Hyperion Environmental Test Requirements	12-2
12.2.1-2a	Hyperion Protoflight Environmental Test Levels.....	12-2
12.2.1-2b	Hyperion Acceptance Environmental Test Levels.....	12-2
12.2.2.1-1	Hyperion Sinusoidal Vibration Test Levels	12-3
12.2.2.2-1a	Hyperion HSA Acceptance Random Vibration Test Levels.....	12-4
12.2.2.2-1b	HSA STM Structure Protoflight Random Vibration Test Levels.....	12-4
12.2.2.2-1c	Hyperion HEA and CEA Protoflight Random Vibration Test Levels.....	12-4
12.2.2.2-2a	Preliminary HSA Notched Acceptance Random Vibration Test Specification	12-5
12.2.2.2-2b	Preliminary HSA STM Notched Protoflight Random Vibration Test Specification.....	12-5

Appendix A. Hyperion Connector Specifications and Pin Assignments

Appendix B. Hyperion Command and Telemetry

Appendix C. 32-Wire RS-422 Image Data Format

Abbreviations and Acronyms

Section 1. Introduction

This interface control document (ICD) describes the characteristics of the Hyperion instrument and defines the interface design requirements for placement of the Hyperion instrument on the Earth Orbiter-1 (EO-1) spacecraft.

1.1 Scope

This ICD contains the specific interface requirements for the Hyperion instrument, including those of the Hyperion Sensor Assembly (HSA), the power and control electronics [Hyperion Electronics Assembly (HEA)], and the cryocooler control electronics [Cryocooler Electronics Assembly (CEA)]. The requirements defined include mechanical characteristics, structural design criteria, mass properties, electrical connections, thermal control, commanding, telemetry, and power.

1.2 Applicability

This ICD applies to the Hyperion instrument that will be flown on the EO-1 spacecraft.

1.3 Approval

This ICD will be approved and signed by authorized representatives of the TRW Hyperion Project Office, the Goddard Space Flight Center (GSFC) EO-1 Project Office, and Swales EO-1 Spacecraft Project Office. The approved document becomes effective immediately and is binding on the participating organizations until a revision is mutually agreed to and properly identified and documented.

1.4 Revisions

The request for revisions to this ICD shall be transmitted in written form to the Hyperion Project Manager and shall include the following:

- Name of initiating engineer/manager and organization
- Description of change
- Date by which change is needed
- Justification for change
- Relationship to previously submitted changes
- Impact, if any

The TRW Hyperion Project Manager shall review and negotiate the requested changes. Changes shall be approved by authorized representatives of GSFC. Upon completion of the signature cycle, the changes shall become effective immediately. The Hyperion system engineer shall be responsible for updating the ICD to reflect revisions and shall also maintain documentation of all

requests for revisions, whether approved or not. All updates to the Hyperion ICD shall be reviewed and approved by the Configuration Control Board (CCB).

1.5 Applicable Documents

1.5.1 Drawings

<u>868590-1</u>	<u>Hyperion Electronics Assembly</u>
<u>868648-1</u>	<u>Hyperion Cable Assembly</u>
868649-1	Hyperion Electronics Assembly <u>Interface Control Drawing</u>
<u>868650-1</u>	<u>Hyperion Cryocooler Electronics Assembly</u>
868652-1	<u>Hyperion</u> Cryocooler Control Electronics Model Hyperion <u>Interface Control Drawing</u>
868800-1	Hyperion Sensor Assembly, EO-1
A0743	Hyperion Instrument/Satellite Layout, EO-1
A0765	EO-1 Spacecraft and Hyperion ICD Drawing

1.5.2 Specifications

GSFC-426-EO-001	Mission Assurance Requirements for the Earth Orbiter (EO-1) Program
SAI-SPEC-158	EO-1 Verification Plan and Environmental Specification
AM-149-0020(155)	System Level Electrical Requirements, EO-1
SAI-STD-056	EO-1 Spacecraft Subsystem Allocation and Description (for reference, only)
AM149-0050(155)	Data Systems 1773 Interface Control Document, EO-1
ALI-S1002	Internal Interface Control Document: Focal Plane Subsystem to Instrument
CCSDS 102.0-B-2	Consultative Committee for Space Data Systems (CCSDS) Recommendation for Packet Telemetry and Telecommands
MIL-STD-1773A	Military Standard Aircraft Internal Time Division Command/Response Multiplex Data Bus
EQ7-0459	Hyperion Instrument Specification
EQ3-057	Equipment Specification for the HSI VNIR Focal Plan Array
EQ3-0926	Equipment Specification for the HSI SWIR Focal Plan Array
SAI-PLAN-130	EO-1 Integration and Test Plan, Rev. D

1.5.3 Documents

D22886	SSTI Safety Assessment Report
D27445	Hyperion Product Assurance Plan
D27446	Hyperion Integration and Test Plan
D27704	Hyperion Instrument Contamination Control Plan
N/A	AIRS Pulse Tube Cryocooler Safety Assessment Report

Section 2. Hyperion Instrument Overview

2.1 The Hyperion Mission

The Hyperion mission is to provide hyperspectral data for improved Earth surface characterization.

2.2 The Hyperion Mission Objectives

The EO-1 Hyperion Project is to provide a science grade hyperspectral instrument based on existing design and hardware. The instrument will provide Earth observation data with quality calibration for improved Earth surface characterization.

2.3 Instrument Description

The EO-1 Hyperion instrument is a pushbroom scanner, which provides hyperspectral images of the Earth from a 705-km Sun synchronous orbit with a 10:01 AM descending node. The orbit inclination is 98.2 degrees, the orbital period is 98.9 minutes, and the orbit is 1 minute behind Landsat 7. The velocity of the nadir point is 6.74 km/sec. Figure 2.3-1 shows the EO-1 spacecraft in its deployed configuration.

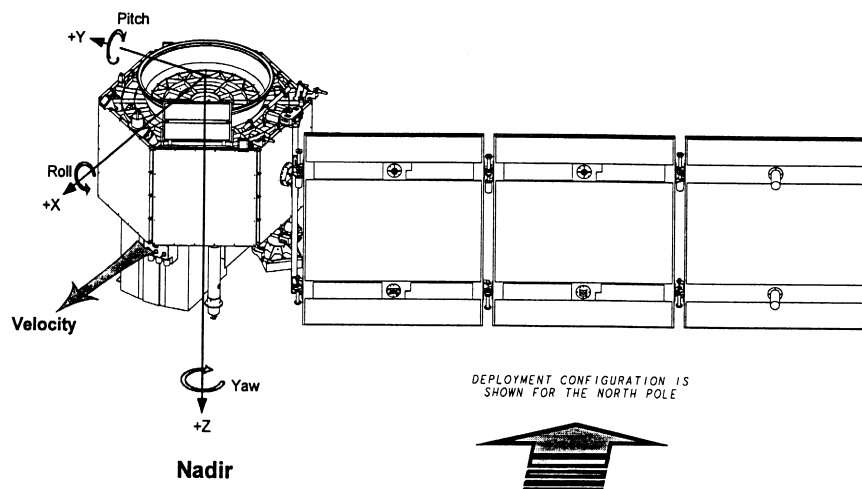


Figure 2.3-1. EO-1 Spacecraft in Its Deployed Configuration

The Hyperion instrument has a visible and near infrared (VNIR) and a shortwave infrared (SWIR) focal plane with a common ground projection that is nominally perpendicular to the along-track direction. The instrument ground sample distance (GSD) is 30 meters. The Hyperion images are composed of 220 spectral bands covering the spectral range from 0.4 μm to 2.5 μm with the spectral resolution of 10 nm.

The Hyperion instrument design utilizes an f/11 Three Mirror Astigmat (TMA) reflective fore optic assembly with a 12.5-cm aperture. The instrument has two Grating Imaging Spectrometers

(GISs) that share the same entrance slit located at the image plane of the fore optics. Each GIS contains a 2-D focal plane array (FPA) located at the image plane of the spectrometer entrance slit. One dimension of the FPA contains the cross-track spatial data while the other dimension has the spectral data for each cross-track spatial pixel.

The Hyperion instrument provides simultaneous image data from 220 spectral bands over 250 cross-track spatial pixels. The normal sampling rate is 223.4 Hz. Data collection is limited by satellite power and data recording capacity.

The Hyperion instrument consists of the HSA and two ancillary electrical boxes, the HEA and the CEA. All three Hyperion subassemblies are located on the nadir deck of the spacecraft (Figure 2.3-2a and b). The HSA is thermally isolated from the nadir deck. It contains the fore optics, the VNIR spectrometer [VNIR GIS, focal plane, focal plane and Analog Signal Processing electronics (VNIR ASP)], and the SWIR spectrometer [SWIR GIS, focal plane, focal plane and Analog Signal Processing electronics (SWIR ASP)]. The HEA is the command, telemetry, and image data interface between the Hyperion instrument and the spacecraft. The HEA also converts the spacecraft bus voltages to the instrument voltage requirements and contains temperature control, calibration source drive, and aperture cover drive electronics. Drawing A0743, "Hyperion Instrument/Satellite Layout, EO-1" (see Figure 2.3-2a and b), shows the locations of the HSA, HEA, and CEA on the EO-1 spacecraft. To align the Hyperion images with the EO-1 Advanced Land Imager (ALI) images, the Hyperion instrument boresight (Z_{Hyperion} -axis) shall be tilted with respect to the EO-1 satellite Z-axis in the -Y direction as defined in Section 4.5.

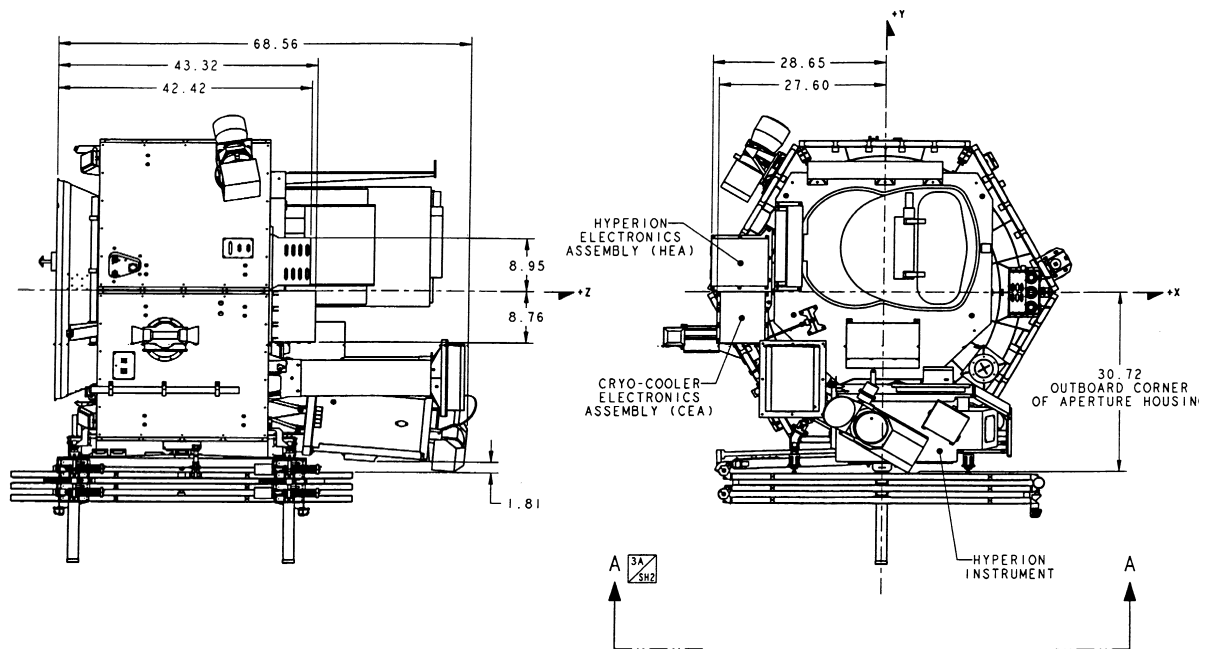


Figure 2.3-2a. Location of the Hyperion HSA, HEA, and CEA on the EO-1 Spacecraft

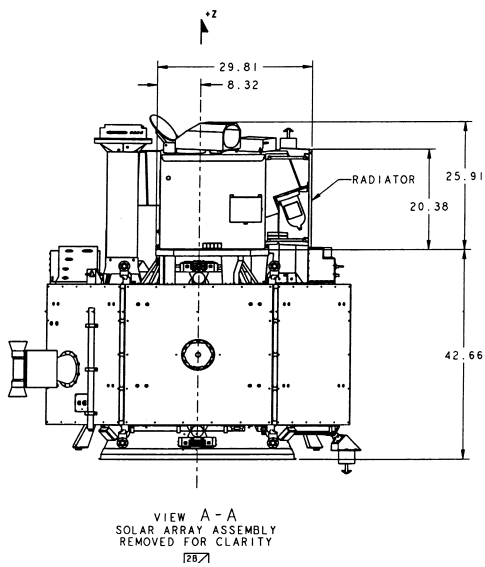


Figure 2.3-2b. Location of the Hyperion HSA, HEA, and CEA on the EO-1 Spacecraft

Section 3. Physical Description

3.1 Overview of Physical Configuration

The Hyperion instrument consists of three assemblies on the EO-1 spacecraft: the HSA, the HEA, and the CEA. A block diagram of the instrument is shown in Figure 3.1-1. The HSA is located on the spacecraft payload platform and is thermally isolated from the platform (see Figure 2.3-2). The HEA and the CEA are located on the spacecraft payload platform (see Figure 2.3-2) and are thermally connected to the spacecraft. The Hyperion instrument requires an interconnected cable harness in addition to the harness between the spacecraft subsystems and the Hyperion. The instrument interconnecting harness shall be provided by the instrument contractor, and the instrument-to-spacecraft harness shall be supplied by the spacecraft contractor. Both harnesses shall be routed by the spacecraft contractor.

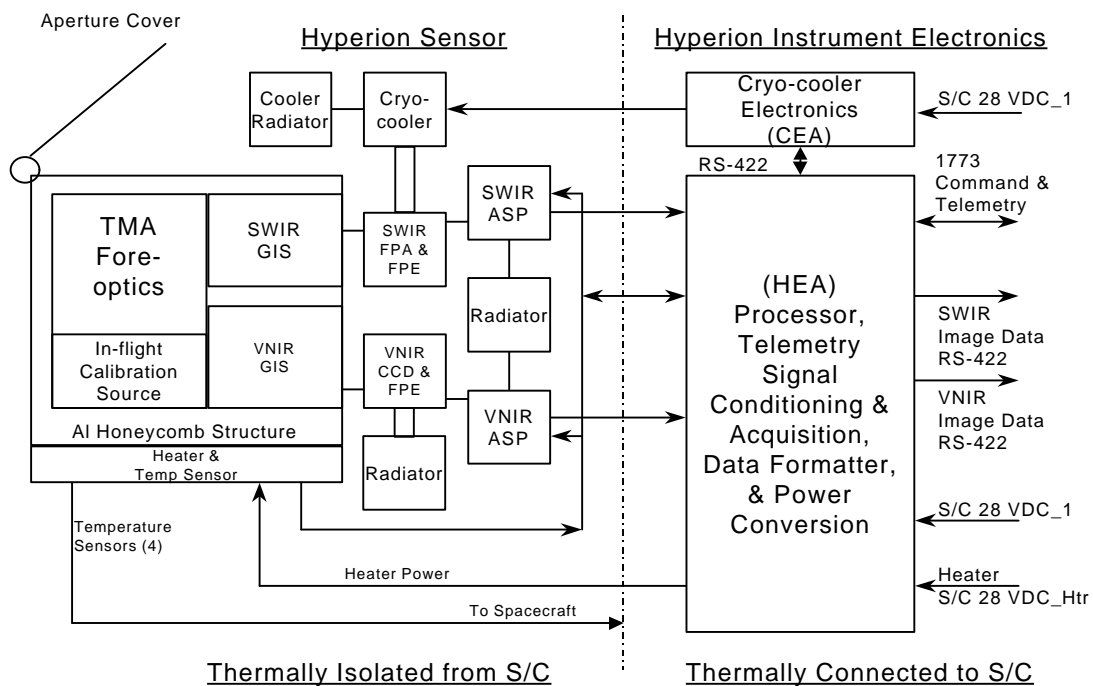


Figure 3.1-1. Hyperion Instrument Block Diagram

3.2 Hyperion Sensor Assembly Description

The HSA components (Figure 3.2-1) include the following:

- HSA structural assembly/enclosure
- Aperture cover assembly (includes cover motor)
- Opto-Mechanical Subsystem (OMS) [includes in-flight calibration source (IFCS)]

- VNIR and SWIR focal planes and focal plane electronics (FPE)
- VNIR and SWIR ASPs
- VNIR radiator
- Cryocooler mechanical assembly and radiator

The OMS is maintained at $20 \pm 2^\circ\text{C}$ by the OMS heaters and thermal shielding provided by the HSA housing. The VNIR focal plane is operated at ~~293K~~ 273K (0°C) and is thermally attached to the VNIR radiator. The SWIR FPA is operated at 115K (-158°C) using cooling from the cryocooler.

The aperture cover protects the instrument optics from particulate and molecular contaminants as well as maintaining the OMS temperature environment. The cover is driven closed against a hard stop during the preflight ground operation and only opens on orbit briefly for imaging/calibration events. The cover is driven by stepper-motor and drive electronics. The aperture cover has three normal positions (open, closed, and solar calibration). The open position is used in taking imaging data. The closed position is used to reflect the internal calibration source into the fore optics for internal calibration of the focal planes. The solar calibration position is used to direct sunlight into the fore optics for calibrating the instrument against the Sun.

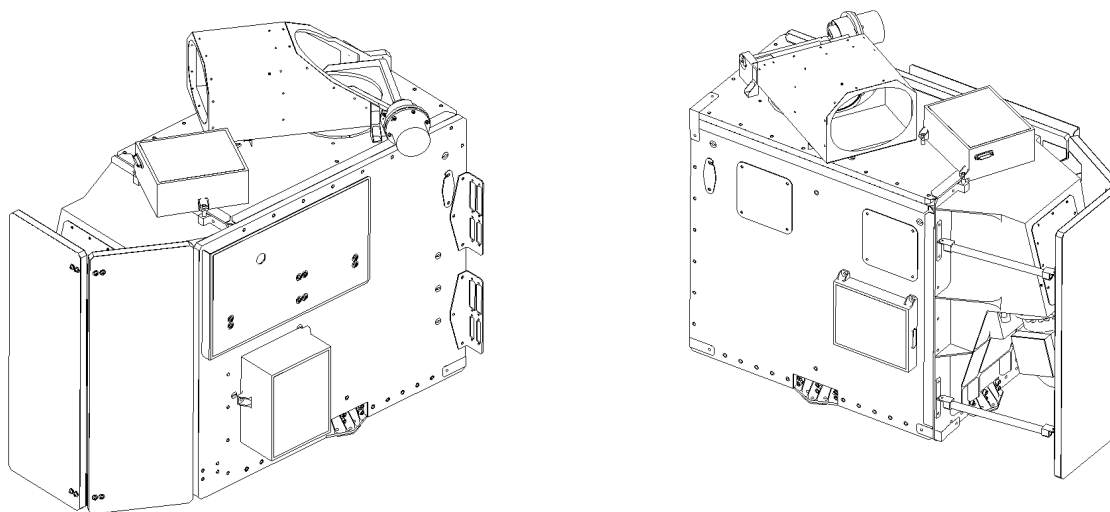
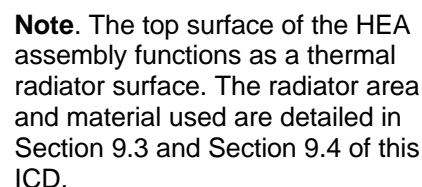


Figure 3.2-1. Hyperion Sensor Assembly

3.3 Hyperion Power and Control Electronics Assembly Description

The Hyperion HEA (Figure 3.3-1) houses the circuits needed to

- Condition spacecraft-supplied power for distribution to the FPE modules (FPM), the ASPs, the cover motor, the heaters, and the IFCS within the instrument



REF DES	PART NUMBER	DESTINATION	REF DES	PART NUMBER	DESTINATION
J101	2A014-111V-001 (9P)	S/C Power	J110	2A065-023V-001 (78S)	VNIR DATA TO S/C
J102	2A014-048V-001 (25S)	LAMP/TEMP SENSOR	J111	2A065-017V-001 (78S)	SWIR DATA TO S/C
J103	2A014-047V-001 (15S)	VNIR ASP POWER	J112	2A014-046V-001 (9S)	CRYOCOOLER I/F
J104	2A014-046V-001 (9S)	SWIR ASP POWER	J113	R2525-4 (JOHANSON)	1773 Data, "A" Tx
J106	2A014-048V-001 (25S)	HEATERS	J114	R2525-4 (JOHANSON)	1773 Data, "A" Rx
J107	2A014-046V-001 (9S)	MOTOR	J115	R2525-4 (JOHANSON)	1773 Data, "B" Tx
J108	2A065-017V-001 (78P)	VNIR ASP	J116	R2525-4 (JOHANSON)	1773 Data, "B" Rx
J109	2A065-023V-001 (78S)	SWIR ASP			

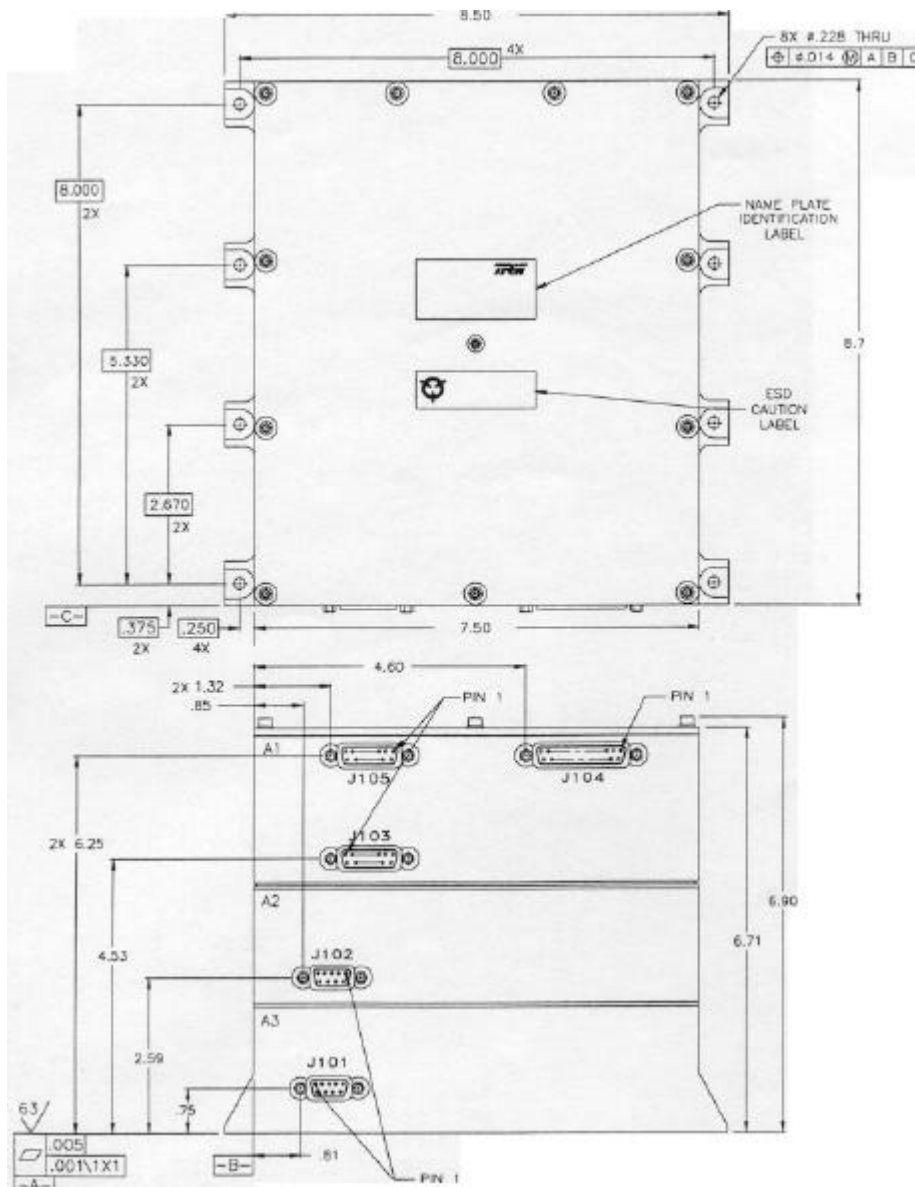
**Figure 3.3-1. Hyperion Power and Control Electronics Assembly (HEA) Interface
(Drawing 868649-1, Hyperion Electronics Assembly *Interface Control Drawing*)**

- Provide timing to clock and read out the FPAs
- Control the ASP gains and offsets
- Control the IFCS
- Measure and maintain the HSA temperatures with controlled heaters
- Receive commands from the spacecraft
- Digitize and distribute telemetry data over the 1773 bus

The HEA is powered by two spacecraft 28+/-7 VDC services. Both power switching and over-current protection of the 28V services are controlled and provided by the spacecraft. One of the 28V services powers the CEA along with the HEA, and the other service supplies heater power during normal operations and in survival mode. The HEA measures and controls the HSA temperature with heaters, and the HEA electronics need to be powered and functional to maintain temperature stability of the HSA.

3.4 Hyperion Cryocooler Control Electronics Assembly Description

The Hyperion CEA (Figure 3.4-1) powers and controls the cryocooler compressor assembly that supplies cooling to the Hyperion SWIR FPA. The CEA power is on the same 28V service as the HEA power, and the two assemblies are switched on and off together. Optimally, after the SWIR FPA is cooled down on-orbit, it is to be maintained at the operating temperature continuously because of the long thermal time constant of the FPA assembly and the FPA sensitivity to thermal cycling. The thermal cycling of the SWIR FPA shall be less than 100 cycles total. The thermal cycling of the SWIR FPA shall be less than 15 cycles during satellite integration and test (I&T).



Note. The top surface of the CEA assembly functions as a thermal radiator surface. The radiator area and material used are detailed in Section .

REF DES	PART NUMBER	DESTINATION	REF DES	PART NUMBER	DESTINATION
J101	M24308/4-1(9P)	S/C Power	J104	M24308/2-3(25S)	ACCEL / LVDT I/F
J102	M24308/2-1(9S)	MOTOR	J105	M24308/2-2(15S)	COLD HEAD I/F
J103	M24308/4-2(15S)	CEA TO HEA I/F			

Figure 3.4-1. Hyperion Cryocooler Control Electronics Assembly (CEA) Interface
(Drawing 868652-1, ~~Cryocooler Control Electronics--Model Hyperion~~Hyperion
Cryocooler Interface Control Drawing)

Section 4. Mechanical Interface

4.1 Overview of the Mechanical Interface

The Hyperion HSA, HEA, and CEA units are mounted on two instrument shelves on the nadir deck of the spacecraft. The HSA is thermally isolated from the spacecraft but rigidly mounted to one instrument shelf at four points using 12 10-32 fasteners. The HEA and the CEA are thermally connected to the spacecraft through the mounting surfaces of the second instrument shelf, and both have thermal radiators to limit heat conducted into the nadir deck. The HEA is secured to the instrument shelf with #8 bolts, and the CEA with #10 bolts. All of the mounting hardware for the HSA, the HEA, and the CEA are to be supplied by the spacecraft contractor.

4.2 Mechanical Interface Reference

The Hyperion EO-1 interface drawing A0765 is the controlling reference that specifies the Hyperion-to-EO-1 spacecraft mechanical interfaces. Other references are as follows:

868800-1	Hyperion Sensor Assembly, EO-1
868649- 1	Hyperion Electronics Assembly Interface Control Drawing
868652- 1	Cryocooler Control Electronics—Model Hyperion Cryocooler Interface Control Drawing

4.3 Instrument Reference Coordinate Systems

The location and orientation of the Hyperion instrument assembly's coordinate system relative to the EO-1 spacecraft reference coordinate system are contained in drawing A0765. The location of the HSA coordinate system is shown in drawing 868800-~~1~~, "Hyperion Sensor Assembly, EO-1." The HSA optical alignment relative to the HSA reference coordinate system shall be specified relative to the optical alignment cube shown in drawing 868800-~~1~~.

4.4 Instrument Sizes

The detailed dimensions of the Hyperion instrument assemblies are specified in drawing A0765 with hardware assemblies shown in drawings 868800-~~1~~, 868~~649-1590~~, and 868652-~~1~~. The maximum dimensions of the assemblies are as follows:

Assembly	Max. Height (inch)	Base (inch)
HSA	25.98	15.2 x 29.5
HEA	6.3	9.0 x 9.6
CEA	7.2	8.50 x 8.75

4.5 Instrument Field of View

The fields of view (FOVs) required by the Hyperion instrument for Earth viewing (imaging) and solar calibration are shown in drawing 868800. The Hyperion Earth-viewing FOV shall be offset 4.84+/-0.05 degrees from the spacecraft +Z axis towards the -Y axis. The FOV shall be less than 1.0 degree (full field) in the cross-track (+Y/-Y) direction and 0.5 degree (full field) in the along-track (+X) direction. A keep-out zone with an additional 15 degrees half angle defined about the center of the imaging and solar calibration FOVs shall be provided by the spacecraft.

The solar calibration FOV shall be along the line in the spacecraft X/Y reference plane, which is located at 23.15 in. along the Z-axis. The FOV will be 1.0 degree by 0.5 degree in the X/Y plane relative to the +Z/-Z axes per drawing A0765. A circular keep-out zone with an additional 30 degrees half angle shall be provided by the spacecraft.

The clearances necessary for the HSA radiators' FOVs are detailed in the drawing A0765.

4.6 Mass Properties

The maximum masses of the Hyperion instrument assemblies are as follows:

Assembly	Mass (kg)
HSA	35.0
HEA	7.0
CEA	7.0

4.7 Center of Mass

The center of mass locations for the Hyperion instrument assemblies in the assembly references are as follows:

Assembly	Assembly References (in +/- 0.10 in)
HSA	X=8.15, Y=0.55, Z=9.79 (Note 1)
HEA	X=0.0, Y=0.0, Z=2.5
CEA	X=0.0, Y=0.0, Z=3.5

Note 1: X, Y, Z=0 where boresight intersects base of HSA.

4.8 Mounting, Drill Template, Alignment, and Access

4.8.1 Mounting

The HSA shall be mounted at four locations with fiberglass spacers (see drawing 868800-1) to the instrument shelf on the nadir deck.

4.8.2 Drill Template

The HSA mounting holes shall be transferred from the drill template provided by TRW. The spacecraft shall provide two alignment pins for the accurate location of the drill template.

The HEA and CEA mounting holes shall be transferred from tooling holes for alignment. No drill templates are needed.

4.8.3 Alignment

The HEA and the CEA alignments are not critical and shall be according to drawing A0765.

The HSA alignment requirements are specified in drawings A0765 and 868800-1 and are discussed below. All alignment is with respect to the ALI boresight.

4.8.3.1 HSA X-Axis Alignment

The Hyperion boresight rotation about the X-axis is the most critical and shall be controlled to ± 0.05 degree. [0.05 degree converts to 180 arcsec or 872.7 μ rad, and is (705 km x 872.7 μ rad) 615 m in the across-track swath location.]

The HSA will be shimmed to within the correct tolerance, and to limit the amount of shimming to less than 0.61 degree, the following alignments are necessary:

1. The HSA optical cube shall be measured with respect to the Hyperion boresight to within 0.01 degree. [0.01 degree converts to 36 arcsec or 174.5 μ rad, and is (705 km x 174.5 μ rad) 123.0 m in the along- and across-track dimension.]
2. The HSA mounting surface shall be perpendicular to the HSA boresight to within 0.1 degree. [0.1 degree converts to 360 arcsec or 1745.3 μ rad, and is (705 km x 1745.3 μ rad) 1230.4 m in the along- and across-track dimension.]
3. The spacecraft instrument shelf shall be within 0.5 degree of the correct angle.

4.8.3.2 HSA Y-Axis Alignment

The HSA shall be aligned to within 0.5 degree in rotation about the Y-axis. This is within the manufacturing tolerances of the spacecraft instrument shelf. [0.5 degree converts to 1800 arcsec or 8276.5 μ rad, and is (705 km x 8276.5 μ rad) 6152 m in the along-track position.]

4.8.3.3 HSA Z-Axis Alignment

The two HSA alignment pins shall be aligned to within 0.5 degree in rotation about the Z-axis. [0.5 degree converts to 1800 arcsec or 8276.5 μ rad, and is (0.5 x 7680 m x 8276.5 μ rad) 31.8 m, or about 1 pixel, in the along-track position.]

4.8.4 Access

The Hyperion instrument has an alignment cube mounted on the OMS inside the HSA housing. There are access covers on the HSA housing (drawing 868800-1) to allow viewing of the

alignment cube inside to facilitate installation and alignment of the Hyperion on the EO-1 spacecraft.

The Hyperion instrument does not require external access to test points.

4.9 Base-Plate Flatness

The mounting surfaces of the HSA, HEA, and CEA shall be flat to ± 0.005 in. to ensure the required electrical and thermal contacts as well as the required alignment of the Hyperion to the spacecraft coordinates. The spacecraft mounting plate shall be flat to the tolerance of ± 0.010 in. The HSA mounting surface characteristics are specified in drawing 868800-1. The HEA mounting surface characteristics are specified in drawing ~~868590~~868649-1. The CEA mounting surface characteristics are specified in drawing 868652-1.

4.10 Aperture Cover Operation and Uncompensated Angular Momentum

The nominal HSA aperture cover operation timing is summarized in Table 4.10-1.

Table 4.10-1. Hyperion Aperture Cover Operation Timing

Operation	Estimated Duration
Cover open (imaging)	15 seconds
Cover close (imaging)	15 seconds
Cover open (solar calibration)	5 seconds
Cover close (solar calibration)	5 seconds

The ~~rotational inertia and maximum velocity of the~~ aperture cover and angular velocity are 6.05 are TBD kg-cm² and 0.16 radian/sec. The cryocooler compressor self-induced vibration is <0.2 N on axis (0 to 1 kHz) and is <0.1 N off axis (0 to 1 kHz).

Section 5. Electrical Interface

5.1 Overview of the Electrical Interface

The Hyperion electrical interface block diagram is shown in Figure 5.1-1. The Hyperion external electrical interface consists of two switched power services, a 1773 command and telemetry interface, and two 32-cable (twisted pair) RS-422 image data interfaces. The Hyperion instrument does not employ any bilevel command line nor any pulsed command line. The command and telemetry interface and the science data interface are discussed in Sections 6 and 7, respectively.

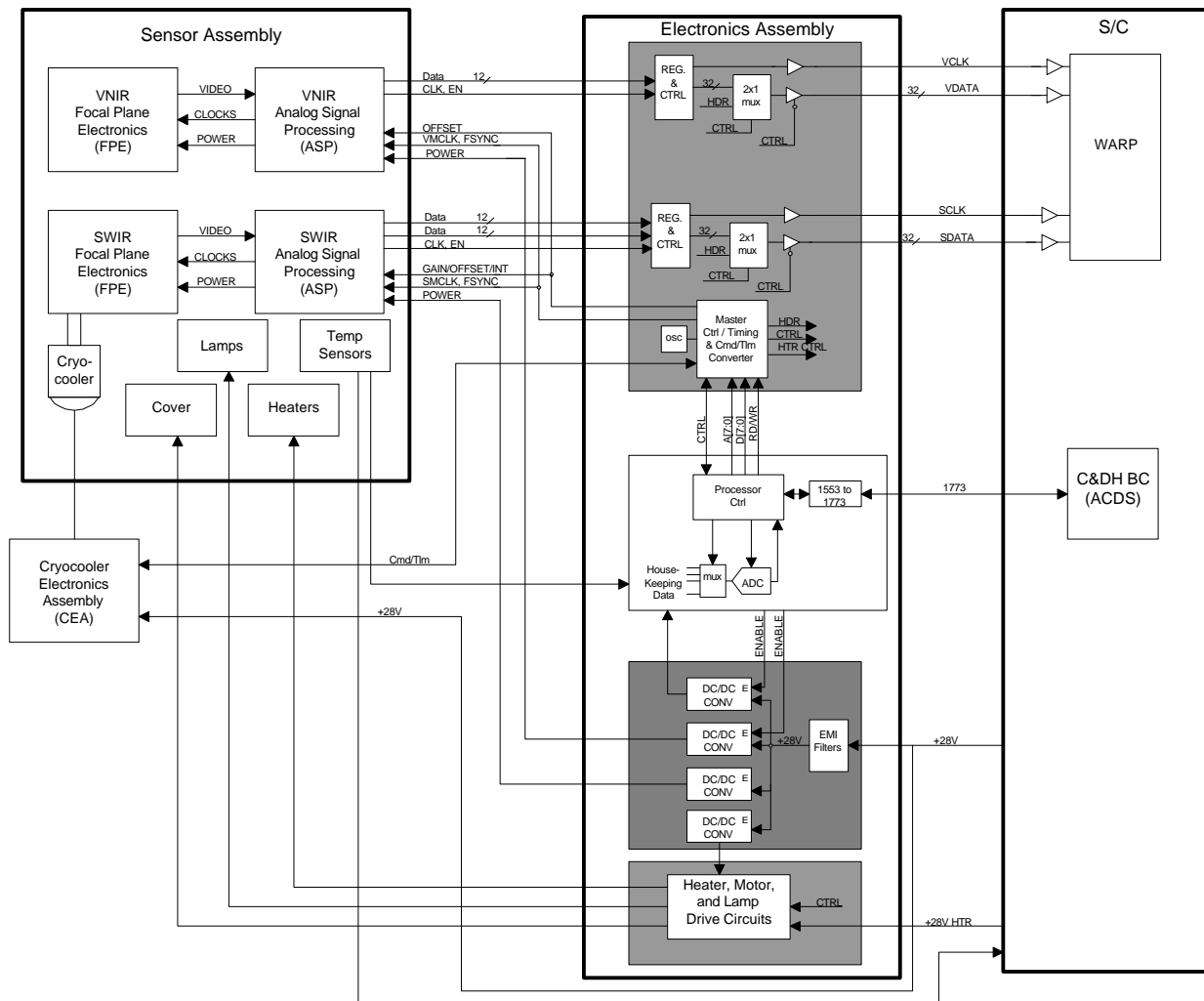


Figure 5.1-1. Hyperion Spacecraft Electrical and Data Interface Diagram

The Hyperion instrument shall meet all the electrical interface requirements in “System Level Electrical Requirements, EO-1,” AM-149-0020(155).

5.2 Electrical Interface Harness

The Hyperion external harnesses between the spacecraft and the Hyperion instrument (Figure 5.2-1) consists of (1) the 1773 harness, (2) the image data RS-422 harness, and (3) the power supply harness. The instrument interconnecting harness shall be provided by the instrument contractor, and the instrument-to-spacecraft harness (external harness) shall be supplied by the spacecraft contractor. Both harnesses shall be routed by the spacecraft contractor.

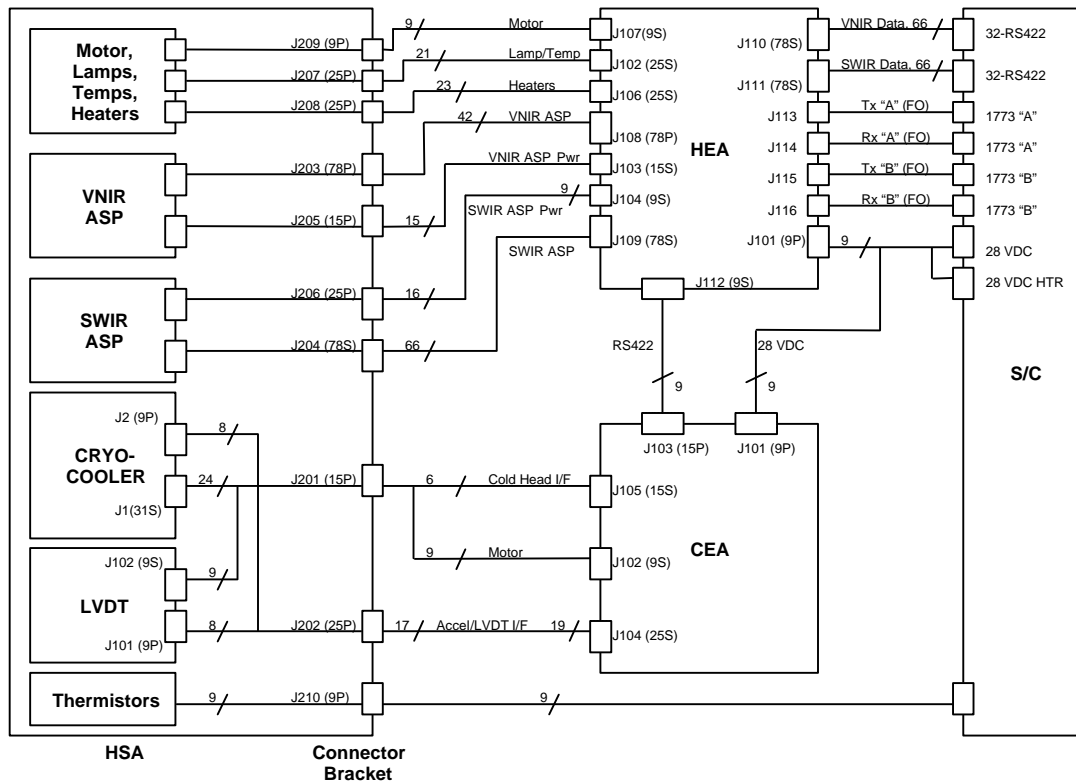


Figure 5.2-1. Hyperion Cable Diagram

The Hyperion instrument shall provide, to the spacecraft, temperature monitoring at four critical points on the HSA. The temperature sensors shall be SP44905 YSI thermistors, GSFC part number S311P18-05A76R, and shall have the characteristic of 5K Ohms at 25°C. The thermistor wires shall be routed to a 9-pin D-connector for mating to the spacecraft. Detailed pin assignments of the connector are included in Appendix A. The spacecraft shall provide measurement and telemetry of these four temperature sensors.

The external Hyperion harness connector specifications, wire specifications, and pin assignments are given in Appendix A.1.

The Hyperion internal harnesses (see Figure 5.2-1) are between (1) the HEA/HSA assemblies, (2) the CEA/HSA assemblies, and (3) the HEA/CEA assemblies. The harness assemblies shall be supplied by the Hyperion instrument contractor, and the harnesses shall be routed by the spacecraft contractor.

5.3 Power Control

The spacecraft shall provide Hyperion power line over-current protection and shall control switching of the power lines.

5.3.1 Over-Current Protection

5.3.1.1 Over-Current Protection Requirements

The over-current protection requirements for the two Hyperion switched power lines are listed in Table 5.3.1.1-1.

Table 5.3.1.1-1. Hyperion Over-Current Protection Requirements

	Over-Current Protection Requirement (A.)
HEA_28V_1	15
HEA_28V_HTR	15

5.3.1.2 In-Rush Current

The Hyperion instrument shall control the HEA_28V_1 and the HEA_28V_HTR power line in-rush current to meet the requirements in AM-149-0020(155).

5.4 Spacecraft Bus Voltages

The Hyperion instrument electronics shall condition, convert, and operate at the spacecraft bus voltage of 28 \pm 7 VDC. The \pm 7 VDC variations of the spacecraft bus voltage shall include the \pm 1.5V voltage ripple. The Hyperion electronics shall survive without damage bus voltages of 0V to +40 VDC.

5.5 Hyperion Power Consumption

The Hyperion power consumption shall not exceed the total power values shown in Table 5.5-1.

Table 5.5-1. Hyperion Instrument Power Consumption

Operation Mode	Total Power (Watts)	Margin	HEA_28V_1	HEA_28V_HTR
Idle	59.4	2.8	52.8	3.8
Standby	103.5	4.6	94.7	3.8
Imaging	103.5	4.9	94.7	3.8
Lamp calibration	141.0	6.7	130.5	3.8
Cover operation	123.2	5.9	113.5	3.8
Survival	25.1	1.2	0.0	23.9

5.6 Electrical Grounding and Shielding

The HSA is isolated from the spacecraft platform and shall have a single-point grounding strap connection to the nadir deck. The ground strap shall meet the requirements of AM-149-0020(155).

The pickup point for the grounding strap shall be one of the HSA side-panel fasteners located on the -X side of the HSA module. The spacecraft contractor shall supply the ground strap and the grounding lug on the spacecraft.

The instrument electrical grounding scheme shall conform to the requirements detailed in AM-149-0020(155)

The Hyperion primary power return impedance shall meet the requirements detailed in AM-149-0020(155).

The Hyperion signal return shall be connected to the chassis according to the requirements detailed in AM-149-0020(155).

5.7 Electrical Isolation

At the interface, between power and signal lines, the Hyperion shall provide a DC and an AC isolation that meet the requirements of AM-149-0020(155).

Section 6. Command and Telemetry

6.1 Command and Telemetry Overview

The on-orbit operation of the Hyperion requires command uplink from the ground through the spacecraft computer. The Hyperion uses two command uplink modes: real-time command uplink and time-tagged command uplink for flight operations. The nominal operation of Hyperion will use time-tagged command uplink.

The spacecraft reformats the uplinked commands before distributing them to the Hyperion. The Hyperion shall use a 1773 bus for spacecraft command and telemetry interface, and the bus protocols shall conform to AM-149-0050(155) "Data Systems 1773 ICD, EO-1" specifications. The 1773 harness shall be supplied by the spacecraft contractor.

When the spacecraft applies power to the power interface of the Hyperion HEA, the instrument transitions from unpowered condition to idle mode. Initial power up also enables the instrument processor, loads the instrument flight software, collects state of health data, starts the temperature and heater control, and enables the 1773 command and telemetry interface. After the initial power up, the 1773 bus is used to provide instrument command and telemetry support.

When the spacecraft applies power to the CEA interface, the CEA shall boot up from ROM software and shall be ready to establish RS-422 communication with the Hyperion HEA unit. The Hyperion CEA command and telemetry functions are supported and rerouted to the spacecraft by the HEA via the 1773 interface.

6.2 Discrete Command and Telemetry Interfaces

Discrete interfaces are bilevel command lines and pulse command lines. The Hyperion instrument has no bilevel and pulse command interface.

6.3 Power-Off Command Sequence Restriction

6.3.1 Power-Off Command Sequence

Before the ACDS main processor removes power from Hyperion, the spacecraft shall provide a close cover command to the Hyperion at least 30 seconds prior to a power off sequence. This is to prevent the Hyperion from viewing the Sun directly through the instrument aperture during anomalous spacecraft conditions.

Abrupt termination of Hyperion power can occur if a spacecraft low-power condition follows a loss of 1773 communications. Abrupt termination of bus power supply to the Hyperion without closing the aperture cover may result in damage to the Hyperion instrument.

6.3.2 Loss of 1773 Time Code "Tone Message"

The Hyperion shall monitor 1773 Time Code "Tone Message" broadcast each second at the schedule time of 0.000. If no tone message is detected for 10 seconds, the Hyperion shall initiate the internal command sequence to close the instrument cover and put the Hyperion in idle mode.

6.3.3 Safehold Command

The spacecraft shall provide a safehold command to the Hyperion in advance of the instrument emergency shutdown procedure. After receiving a safehold command, the Hyperion shall close the aperture cover and transit into idle mode, with the ASPs power off, within 30 seconds.

6.4 1773 Command and Telemetry Data Bus

The Hyperion instrument shall use a MIL-STD-1773 fiber optics serial bus to conduct command and telemetry functions. The Hyperion (RT) 1773 controller shall be a Boeing 1300 nm, Litton part number 900-60095-12, transceiver. The 900-60095-12 transceiver shall be supplied by GSFC. The 1773 bus shall meet the specifications in AM149-0050(155). Measured parameters delivered with the Hyperion shall include power output receiver sensitivity and receiver saturation values for both A and B bus transceivers. The spacecraft contractor shall supply and route the 1773 interconnecting harness to the Hyperion.

The spacecraft Flight Data System (FDS) software residing on the ACDS main processor (Mongoose V) shall operate as the bus controller (BC), and the Hyperion instrument shall operate as a remote terminal (RT). The RT address ID for the Hyperion shall be 12 (01100). The FDS BC software implements a time division multiplexed bus schedule for communication with the various subsystems on the spacecraft. The details of the command and telemetry packet sizes, CCSDS application identification numbers, channels, and packet transfer data rates are detailed in AM149-0050(155).

6.5 Command and Telemetry Packet Protocol

The primary data transfers in the spacecraft are in the form of CCSDS packets. The Hyperion instrument shall format the telemetry data to comply with, and shall be capable of processing received data that was formatted according to, the CCSDS recommendations for packet telemetry. The spacecraft bus schedule for the Hyperion is shown in Table 6.5-1. The Hyperion shall use the BOX_CMD and the HYP_CMD_SUBCOM schedules to receive command and instrument parameters from the spacecraft, and shall use the HYP_SOH_TLM and the HYP_SUBCOM schedules to send data to the spacecraft.

Table 6.5-1. Hyperion Spacecraft Bus Schedule

Time (sec.)	Packet	Time (sec.)	Packet
.048	BOX_CMD	.528	BOX_CMD
.128	BOX_CMD	.592	BOX_CMD
.208	BOX_CMD	.680	BOX_CMD
.248	BOX_CMD	.720	BOX_CMD
.280	HYP_CMD_SUBCOM	.784	BOX_CMD
.288	BOX_CMD	.856	BOX_CMD
.344	BOX_CMD	.904	HYP_TLM_SUBCOM
.424	BOX_CMD	.928	BOX_CMD
.464	BOX_CMD	.984	BOX_CMD
.520	HYP_SOH_TLM		

The CCSDS packets shall be transferred over a channel (a set of sequential 1773 subaddresses). Channels shall be multiples of 32 16-bit words (one complete subaddress). The most significant bytes of a packet (the packet header) shall be transferred in the lowest subaddress. The Hyperion channels are defined in Table 6.5-2.

Table 6.5-2. Hyperion Instrument Command and Telemetry Channel Definitions

Channel Definition	Start Subaddress	End Subaddress	Completion Subaddress	Bus Schedule	RSN Queues
BC-to-RT Command Channels					
RCH1	1	1	2	Box commands	Instrument commands
RCH2 @ 1/4 Hz max.	3	20	21	0.280	Cryocooler commands
RT-to-BC Telemetry Channels					
XCH2 @ ¼ Hz max.	3	18	19	0.904	Cryocooler telemetry
XCH3 @ 1 Hz max.	20	23	24	0.520	Instrument telemetry

6.6 Telemetry Packet Format and Acquisition

The transfer of packets is governed by two protocols, a BC-to-RT packet transfer and an RT-to-BC packet transfer.

6.6.1 Telemetry Packet Format

The Hyperion telemetry packet shall conform to CCSDS packet telemetry recommendations. A primary header shall be attached to the telemetry data. In addition, the time code shall be included in the secondary header. The telemetry packet format and telemetry list is detailed in Appendix B.

6.6.2 Telemetry Packet Acquisition

The channel subaddresses shall be read consecutively. Only “new data” is recorded or transmitted. The first 16-bit word in the first subaddress shall be used as a semaphore. If the semaphore value is zero or the same as the previous read, the channel does not contain “new data.” The BC shall read from the completion subaddress to signal to the RT that the channel read is completed.

6.7 Command Packet Format and Distribution

6.7.1 Command Packet Format

The spacecraft distributes commands in CCSDS packets. The application ID and functional code of the command packet are used to identify the RT and the channels. The command packet header, data format, and command list are detailed in Appendix B.

6.7.2 Command Packet Distribution

The BC shall write consecutively to the subaddresses in a channel and shall write to the completion subaddress to signal the completion of a data transfer.

6.8 Time Code Distribution

The FDS shall deliver a time code update to the Hyperion instrument once per second. The time code update shall be delivered in two command packets, a “tone message” packet and an “at the tone the time was” packet. The time code data shall correspond to the first bit of the “tone message” command packet. The channel definition and the application ID for time distribution are shown in Table 6.8-1.

Table 6.8-1. Time Code Distribution Channel Definition

Time Synchronization Command Remote Terminal 31 (Broadcast)					
Channel Definition	Start Subaddress	End Subaddress	Completion Subaddress	Max Packet Size (16-bit words)	Typical Use
Tone	29	N/A	N/A	32	Once per second Schedule 0.000
Time	28	N/A	N/A	32	Once per second Schedule 0.088

The “tone message” packet is a command packet with a 6-byte primary header, a 2-byte secondary header, and command data consisting of a 16-bit sequence counter and a 64-bit time code. The “at the tone the time was” packet has a 6-byte primary header and a 2-byte secondary header, plus a 16-bit sequence counter and a 64-bit time code. The mock code sent shall be 8 (01000).

6.9 Reset Command Packet

In addition to a power up processor reboot, the Hyperion shall respond to a reset command from the spacecraft. The channel definition and the application ID for time distribution are shown in Table 6.9-1.

Table 6.9-1. 1773 Reset Command Channel Definition

Time Synchronization Command Remote Terminal 31 (Broadcast)					
Channel Definition	Start Subaddress	End Subaddress	Completion Subaddress	Max Packet Size (16-bit words)	Typical Use
Reset	0	N/A	N/A	0	Schedule 0.480

6.10 Wraparound Data

The wraparound data provision is to verify the proper operation of the 1773 bus. The Hyperion instrument shall use the receive subaddress #30 to receive BC data up to 32 16-bit words and make the same data available for read out by the BC at transmit subaddress #30.

Section 7. Image Data Interface

The Hyperion shall provide image data collection capability in support of the mission objective. The image data shall be formatted and transmitted to the Wideband Advanced Recorder/Processor (WARP) for storage using two 32-cable RS-422 data buses, one for the VNIR data and one for the SWIR data. The total data volume for each image data collection shall be less than the WARP data storage capacity of 40 Gb.

7.1 32-Cable RS-422 Image Data Interface

7.1.1 Image Data Ports

The two 32-cable RS-422 image data buses shall be connected to the WARP interface ports J4 and J5. Port J4 shall be the Hyperion VNIR data port, and port J5 shall be the Hyperion SWIR data port.

7.1.2 Image Data Interface Circuit, Connector and Pin Assignments

The Hyperion 32-cable science data connector shall be a 78-pin socket type D-connector, and the connector pin assignments shall be as detailed in Appendix A.2.

An example of an interface transceiver circuit is shown in Figure 7.1.2-1. All transmitters shall be either a Harris HS-26C31RH or HS-26CT31RH, and all receivers shall be either a Harris HS-26C32RH or HS-26CT32RH. The receiver inputs shall be AC terminated with a 120-Ohms resistor and a 100-pf capacitor.

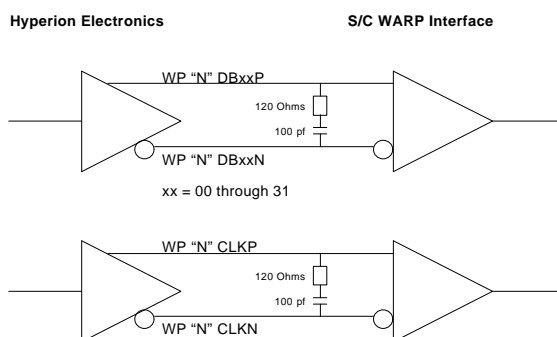


Figure 7.1.2-1. Example of Image Data Interface Transceiver Circuit

7.1.3 Image Data Timing

The two 32-cable RS-422 science data interfaces shall be RS-422 compatible configured with the disconnect state at logic 0 (logic 1 at the receiver output). Associated with each 32-bit data word shall be a gated data clock that controls the strobing of the data into the WARP interface. There shall be no activity (logic 1) on the port clock prior to a data transfer, and the port clock shall stop completely after the last read cycle of a data transfer. Detailed data timing shall be as shown in Figure 7.1.3-1.

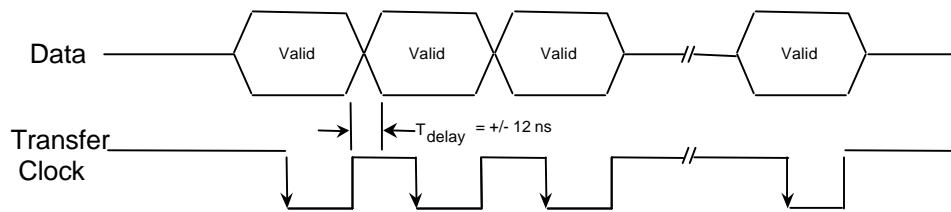


Figure 7.1.3-1. Hyperion Image Data Interface Bit Leveling

7.1.4 Image Data Header

The image data are stored as VNIR frames and SWIR frames. Each frame shall consist of a header followed by the image data. The VNIR frame header shall consist of four 32-bit words, and the SWIR frames header shall consist of five 32-bit words. Details of the header format shall be as detailed in Appendix C.

7.1.5 Image Data Format

Each 32-bit science data word shall consist of two 12-bit pixel data words (DB0:11 and DB16:27), each with a 4-bit header (DB12:15) and (DB28:31). DB11 and DB27 shall be the MSB of the 12-bit science data, and DB0 and DB16 shall be the LSB. Details of the image data format are given in Appendix C.

7.1.5.1 VNIR Image Data Format

The Hyperion VNIR FPA is fabricated to SSTI/HIS Equipment Specification EQ3-057, "Equipment Specification for the HSI VNIR Focal Plane Array." The VNIR frame rate is 223.4 Hz and matches the SWIR frame rate. The nominal frame rate shall be constant to 0.5 Hz (3 sigma) for 3 minutes. The VNIR frame timing detail is shown in Figure 7.1.5.1-1.

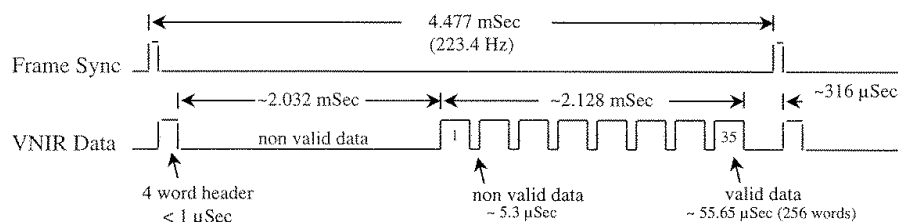


Figure 7.1.5.1-1. Hyperion VNIR Data Frame Timing

The VNIR FPA contains 384 spectral x 768 spatial pixels with a 20 μm pixel pitch. The FPA readout is partitioned into four quadrants with a separate readout port for each quadrant. The VNIR FPA electronics provide a 3 pixel x 3 pixel aggregation while clocking the data off the FPA. After the pixel aggregation, the FPA has 128 spectral and 256 spatial pixels. Each aggregated pixel data is digitized to a 12-bit data word. Seventy contiguous 10-nm spectral bands

shall be read out as VNIR science data. Sixty spectral bands shall be the requirement signal bands, and 10 spectral bands shall be included to facilitate the alignment process. The science data volume for the VNIR channel, frame header included, is 286,848 bits (8964 32-bit words) per frame. The data rate, at 223.4 frames per second, is 64,081,843.2 bits per second (2,002,557.6 32-bit words per second).

7.1.5.2 SWIR Image Data Format

The Hyperion SWIR focal plane, FPE, and ASP are being fabricated to Equipment Specification EQ3-056, "Equipment Specification for the HSI SWIR Focal Plane Array." The SWIR frame rate is 223.4 Hz and matches the VNIR frame rate. The nominal frame rate shall be constant to 0.5 Hz (3 sigma) for up to 3 minutes in duration. The SWIR frame timing detail is shown in Figure 7.1.5.2-1.

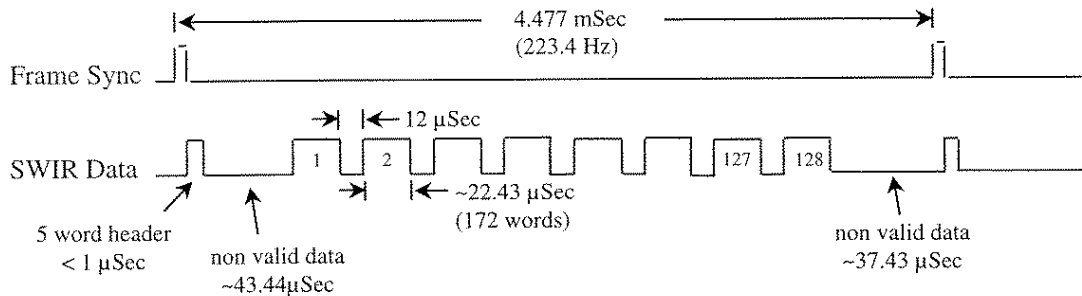


Figure 7.1.5.2-1. Hyperion SWIR Data Frame Timing

The SWIR FPA contains 256 spectral x 256 spatial pixels, and the FPA data readout is partitioned into four readout ports. Each pixel data is digitized into a 12-bit word. One hundred seventy-two contiguous 10-nm SWIR spectral bands shall be read out as SWIR science data. One hundred sixty spectral bands shall be the required bands, and 12 extra spectral bands shall be read out to facilitate the alignment process. The total data volume is 704,672 bits (22,021 32-bit words) per frame. The data rate, at 223.4 frames per second, is 157,432,724.8 bits per second (4,919,491.4 32-bit words per second).

Section 8. Hyperion Pointing Allocation

8.1 Spacecraft Pointing Knowledge Budget

8.1.1 Spacecraft Position Knowledge

The spacecraft position knowledge from GPS is 450 m, 3 sigma.

8.1.2 Spacecraft Attitude Knowledge

The spacecraft yaw knowledge is 80 arcsec. The roll error is 80 arcsec, and the pitch error is 100 arcsec.

8.2 Hyperion-to-Spacecraft Pointing Error Allocation

8.2.1 Hyperion Alignment Cube to Spacecraft Attitude Vector Error Allocation

The Hyperion alignment cube vector to the spacecraft attitude coordinate system error shall be known to less than 16 arcsec in yaw, 10 arcsec in roll, and 10 arcsec in pitch by ground measurements.

8.2.2 Hyperion Boresight to Alignment Cube Error Allocation

The Hyperion boresight knowledge with respect to the alignment cube shall be less than 16 arcsec in yaw, 10 arcsec in roll, and 10 arcsec in pitch, as measured at TRW.

8.2.3 Hyperion Image Data Time Tag Error

The on-ground correction of spacecraft time shall provide spacecraft time “tone” knowledge to ± 2 ms (13.5 m), 1 sigma.

The Hyperion shall encode the “sync time” (time from spacecraft time tone to Hyperion frame sync) in the science data header to ± 32 μ sec (0.2 m), 1 sigma. Details of the Hyperion science data timetag header timing is shown in Figure 8.2.3-1.

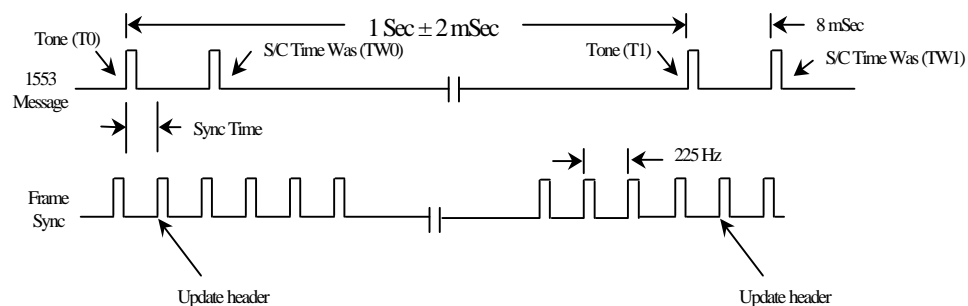
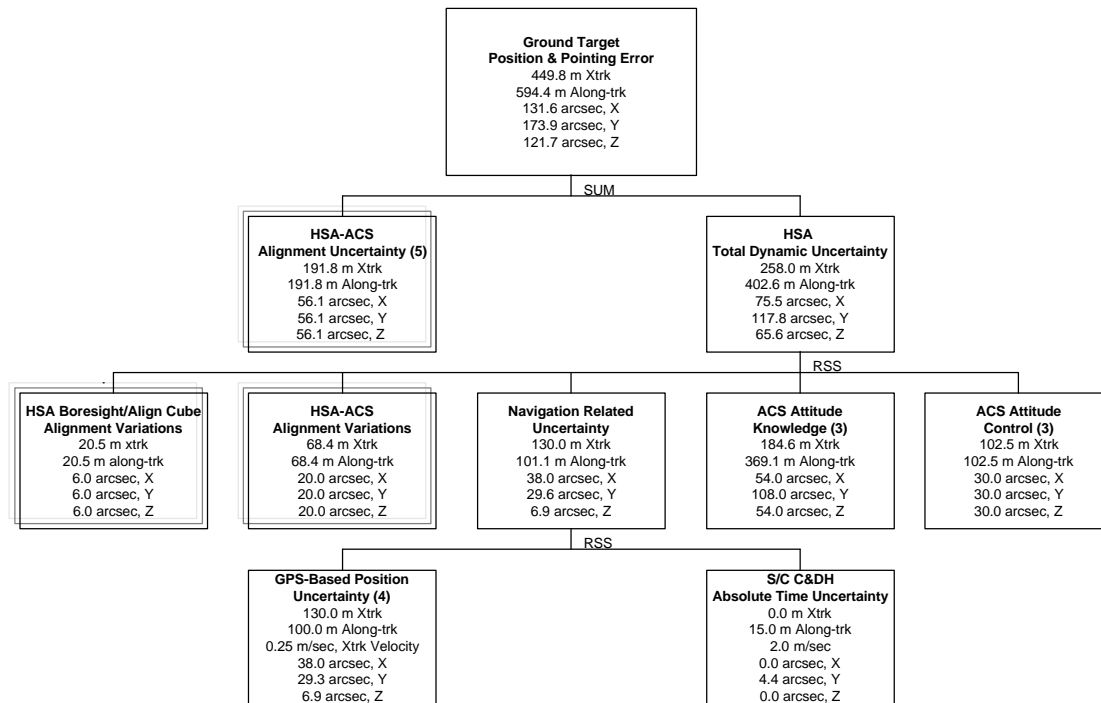


Figure 8.2.3-1. Hyperion Science Data “Time Tag” Timing

8.3 Hyperion Boresight Error Budget

The expected Hyperion image targeting capability (EO-1 Delta CDR, 9/23/98, p. 7-54, by Scott Miller and Paul Sanneman) is summarized in Figure 8.3-1.



1. All numbers are 3-sigma values.
2. Conversion between angles and meters based on 705 km reference altitude.
3. ACS estimates represent expected EO-1/Hyperion nadir pointing capability and depend significantly on star tracker performance.
4. GPS Uncertainties based on 'Phase 1' results of EO-1 Flight GPS Tensor Test Report (6/22/98).
5. HSA-to-ACS Alignment Uncertainty estimate based on post-processing of ACS attitude (30 arcsec), GPS Navigation data (50 m), and Hyperion image recognition/Processing (45 arcsec or 150 m).
6. This budget doesn't include prediction errors related to development of the absolute time command sequence development which will provide ground commands to ACS and initiate the science observation sequence (1 to 3 days predict).

Figure 8.3-1. Hyperion Pointing Error Budget

Section 9. Thermal Interface

9.1 Description

The HSA is mounted on an instrument platform that is attached to the spacecraft nadir deck. The instrument platform and associated hardware are designed to minimize the HSA conductive path to the spacecraft nadir deck. The thermal interface details are specified in drawing A0765.

The HEA and the CEA are mounted on an aluminum mounting plate attached to the nadir deck. The aluminum mounting plate is designed to provide a good conductive path to the HEA/CEA mounting surfaces and to the nadir deck. In addition, the top surfaces of the HEA and CEA electronic boxes are used as passive radiators.

9.2 HSA Thermal Interface

The HSA is thermally isolated from the spacecraft instrument platform using G-10 spacers. The OMS temperature level is controlled by heaters attached to the OMS. Multilayer insulation (MLI) blankets on the HSA exterior are used to minimize heater power consumption and diurnal temperature variations.

Both the VNIR FPA/FPE and the cryocooler pulse tube are supported by the HSA enclosure and have radiators to maintain FPA temperatures at the optimal operation range.

The VNIR ASP and the SWIR ASP are thermally isolated from the HSA enclosure. Temperatures of the ASPs are maintained by radiators.

The detailed thermal design of the HSA and components are shown in Table 9.2-1.

Table 9.2-1. Detailed HSA Thermal Design Characteristics

Subsystem	Survival Temp. (C)	Operating Temp. Capability (C)	Predicted Operating Temp. (C)	Radiator Area (in ²)	Subsystem to S/C Thermal Intf (in ²)	Subsystem to S/C Heat Xfer (W)
HSA	N/A	N/A	N/A	N/A	Per ICD	-2 to +4
Enclosure/LVDT	-25 to +60	-10 to +40	-8 to +16	12	N/A	N/A
OMS	-20 to +40	+18 to +22	+18 to +22	N/A	N/A	N/A
Cryocooler	-40 to +60	-10 to +27	-10 to +27	257	N/A	N/A
VNIR FPA/FPE	-25 to +40	-10 to +15	-10 to +9	105	N/A	N/A
VNIR ASP	-25 to +60	-10 to +40	-8 to +26	22	N/A	N/A
SWIR ASP	-25 to +60	-10 to +40	-8 to +31	24	N/A	N/A

9.2.1 HSA Heat Transfer by Conduction and Radiation

The power consumption of the HSA components is detailed in Table 5.5-1. The conductive heat transfer from the HSA to the nadir deck shall be within the -2W to +4W range.

The HSA enclosure has a 12-in² cold bias radiator, and the detailed radiator provisions for the HSA components are shown in Table 9.2-1.

The HSA radiator locations are defined in drawing A0765.

9.3 HEA and CEA Thermal Interface

The HEA and the CEA are mounted to a plate that is located on the nadir deck of the spacecraft. The top side of each box is designed to act as a radiator with radiator areas to be determined by the spacecraft contractor. The HEA and CEA units shall be conductively mounted on an instrument platform by the spacecraft contractor using Cho-Therm 1671, per drawing A0765. The instrument platform is hard mounted to the nadir deck, which is maintained between 0 and 30°C.

9.3.1 HEA and CEA Heat Transfer by Conduction and Radiation

The power consumption of the HEA and CEA components is detailed in Table 5.5-1. The HEA and CEA radiator maximum dimensions, survival temperatures, and operating temperatures are shown in Table 9.3.1-1. The HEA and CEA radiator locations are defined in drawing A0765.

Table 9.3.1-1. Detailed HEA and CEA Thermal Design Requirements

Subsystem	Survival Temp. (C)	Operating Temp. Capability (C)	Radiator Area (in ²)
HEA	-25 to +60	-10 to +40	128
CEA	-25 to +60	-10 to +40	152

9.4 Surface Treatment and Restrictions

All exterior surfaces of the Hyperion instrument shall be covered with Aluminized Kapton MLI except for radiator areas specified in drawing A0765. The design characteristics of the surface treatments used are detailed in Table 9.4-1. The Hyperion-to-spacecraft MLI closeout shall be a minimum of 2 inches. The instrument contractor shall supply the closeout MLI and the MLI for the Hyperion HSA unit. The spacecraft contractor shall supply the MLI for the Hyperion HEA and CEA units.

Table 9.4-1. Hyperion Surface Treatment Characteristics (a, e)

Material	α_{BOL}	α_{EOL}	ϵ_{BOL}	ϵ_{EOL}
Silvered Teflon (5 mil)	0.07	0.15	0.78	0.78
Aluminized Kapton	0.40	0.60	0.80	0.80
Black Paint	0.96	0.98	0.86	0.86

All exterior surfaces of the EO-1 spacecraft and payloads in the FOV of the Hyperion shall be covered with Aluminized Kapton MLI.

9.5 Thermal Model and Analysis

TRW shall supply an accurate thermal model to Swales Aerospace for confirmation of the thermal interfaces and to assess the impact on the satellite thermal control as required.

Section 10. Electromagnetic Compatibility

The Hyperion shall meet the electromagnetic compatibility requirements per AM-149-0020(155), “System Level Electrical Requirements, EO-1.”

10.1 Electronics Discharge Control

The Hyperion instrument shall be protected from electrostatic discharge by providing proper grounding of the instrument and of personnel to prevent static charge buildup. No static-sensitive circuit connectors will be de-mated/mated or uncovered while the relative humidity is less than 20 percent.

All layers of all MLI on the Hyperion instrument shall be grounded to the spacecraft.

Section 11. Potential Hazards

The Hyperion instrument has no potential hazards as defined in the “SSTI Safety Assessment Report,” D22886.

Section 12. Hyperion Test Interfaces

The “Hyperion Integration and Test Plan,” D27446, contains the specific test levels, the functional and performance tests conducted at each phase of testing, and the equipment and facilities required for the tests. Test data shall be delivered with the Hyperion so that the test and operating teams can evaluate the Hyperion’s health during test and operations.

12.1 Design Requirements

12.1.1 Minimum Natural Frequencies

The minimum natural frequency for the HSA, at the unit mass of 35 kg, shall be greater than 70 Hz in any direction. The HEA and the CEA minimum natural frequency shall be greater than 100 Hz in any direction.

12.1.2 Design Environments

12.1.2.1 Limit Loads

The EO-1 will be launched with a Delta II Med-Lite 7320-10 launch vehicle. The Hyperion instrument shall be designed for the environment specified in SAI-SPEC-158, “EO-1 Verification Plan and Environmental Specification.” The Hyperion shall be designed to withstand 1.25 times the quasi-static loads shown in Table 12.1.2.1-1a and b acting at the center of gravity of the instrument.

Table 12.1.2.1-1a. Flight Limit Loads Factors for the HSA ~~(TBR)~~

Case 1	3.84.1 g axial compression + /-7.3-11.0 g in any lateral direction (TBR)
Case 2	1.0 g axial tension + /-7.3-11.0 g in any lateral direction (TBR)
Case 3	78.19 g axial compression + /-1.10.4 g in any lateral direction (TBR)

- NOTES:**
- (1) Axial direction is parallel to the EO-1 satellite Z-axis.
 - (2) The axial and lateral limit load factors are to be applied simultaneously.
 - (3) Compression is the acceleration sense that produces compression at the spacecraft interface.

Table 12.1.2.1-1b. Flight Limit Loads Factors for the HEA and the CEA

Case 1	15 g in any direction
--------	-----------------------

12.1.2.2 Factor of Safety

The following factors of safety shall be applied to the design loads to derive yield and ultimate stresses:

Test Factors	
Yield	1.25 x
Ultimate stress	1.4 x

No-Test Factors	
Yield	2.0 x
Ultimate stress	2.6 x

12.2 Predelivery Test Requirements

12.2.1 General Test Requirements

The Hyperion environmental test requirements are summarized in Table 12.2.1-1, and the test levels are summarized in Table 12.2.1-2a and b.

Table 12.2.1-1. Hyperion Environmental Test Requirements

	Sine Burst	Sine Vibration	Random Vibration	Shock	Thermal Vacuum	Thermal Balance	Thermal Cycle	EMI/ EMC
HAS	N/A	Protoflight	Acceptance	N/A	Protoflight	Yes	Acceptance	Yes
HEA	N/A	Protoflight	Protoflight	N/A	Protoflight	Yes	Acceptance	Yes
CEA	N/A	Protoflight	Protoflight	N/A	Protoflight	Yes	Acceptance	Yes
STM	1.25x	N/A	Protoflight	N/A	N/A	N/A	N/A	N/A

Table 12.2.1-2a. Hyperion Protoflight Environmental Test Levels

Sine Vibration	Random Vibration	Thermal Vacuum	Thermal Cycles
1.25 x limit load	Limit level + 3 dB	Predicted flight level hot +10°C and cold -10°C	Predicted flight level hot +15°C and cold -15°C

Table 12.2.1-2b. Hyperion Acceptance Environmental Test Levels

Sine Vibration	Random Vibration	Thermal Vacuum	Thermal Cycles
1.0 x limit load	Limit level	Predicted flight level hot and cold	Predicted flight level hot +5°C and cold -5°C

12.2.2 Vibration Tests

The Hyperion shall be in the off mode during instrument level vibration testing. The integration and test plan shall define the functional and performance tests conducted before, during, and after vibration testing.

12.2.2.1 Sinusoidal Vibration

Per SAI-SPEC-158, p. 46, the Hyperion protoflight sine vibration level shall be 1.25 times the estimated flight level vibration amplitudes, and the acceptance level shall be 1.0 times the estimated flight level vibration amplitudes. Table 12.2.2-1 lists the vibration levels and parameters for the HSA, HEA, and CEA assemblies.

Table 12.2.2.1-1. Hyperion Sinusoidal Vibration Test Levels

Frequency (Hz)	Level	Sweep Rate
X axes (Lateral)		
5.0 – 16.1	0.5 in. D.A.	4 Octave/min.
16.1 – 25.0	+/- 6.6 g	4 Octave/min.
25.0 – 35.0	+/- 1.25 g	1.5 Octave/min.
35.0 – 50.0	+/- 1.25 g	4 Octave/min.
Y axes (Lateral)		
5.0 – 18.6	0.5 in. D.A.	4 Octave/min.
18.6 – 25.0	+/- 8.8 g	4 Octave/min.
25.0 – 30.0	+/- 1.5 g	1.5 Octave/min.
30.0 – 35.0	+/- 8.4 g	1.5 Octave/min.
35.0 – 45.0	+/- 8.4 g	4 Octave/min.
45.0 – 50.0	+/- 3.8 g	4 Octave/min.
Z axis (Axial)		
5.0 – 15.0	+/- 0.5 g	4 Octave/min.
15.0 – 20.0	+/- 1.5 g	4 Octave/min.
20.0 – 25.0	+/- 0.5 g	4 Octave/min.
25.0 – 35.0	+/- 0.5 g	1.5 Octave/min.
35.0 – 50.0	+/- 1.0 g	4 Octave/min.

- NOTES:**
- (1) Prototype levels shown are 1.25 times maximum expected flight loads.
 - (2) Levels shown are to be applied at the interface with the EO-1 spacecraft, in each of the three mutually perpendicular axes.
 - (3) The above levels shall be notched at critical frequencies (if required) to limit structural loads to 1.25 times the Hyperion design limit load factors.

12.2.2.2 Random Vibration

Tables 12.2.2.2-1a, b, and c are the Hyperion random vibration test levels. The test levels may be reduced (notched) in specific frequency bands with Project concurrence. The test levels shall be applied at the interface with the spacecraft. The test duration shall be 1 min./axis for each of three orthogonal axes, one of which shall be normal to the mounting surface.

Table 12.2.2.2-1a. Hyperion HSA Acceptance Random Vibration Test Levels

Frequency	Magnitude ¹
20 Hz Hz	0.0065 g ² /Hz
20 - 50 Hz Hz	+6 dB/Octave
50 - 500 Hz Hz	0.040 g ² /Hz
500 - 2000 Hz Hz	-4 dB/Octave
2000 Hz Hz	0.0064 g ² /Hz
Overall Overall	6.4 grms

Table 12.2.2.2-1b. HSA STM Structure Protoflight Random Vibration Test Levels

Frequency	Magnitude ¹
20 Hz Hz	0.0129 g ² /Hz
20 - 50 Hz Hz	+6 dB/Octave
50 - 500 Hz Hz	0.080 g ² /Hz
500 - 2000 Hz Hz	-4 dB/Octave
2000 Hz Hz	0.0127 g ² /Hz
Overall Overall	9.0 grms

Table 12.2.2.2-1c. Hyperion HEA and CEA Protoflight Random Vibration Test Levels

Frequency	Magnitude ¹
20 Hz Hz	0.026 g ² /Hz
20 - 50 Hz Hz	+6 dB/Octave
50 -800 Hz Hz	0.16 g ² /Hz
800 - 2000 Hz Hz	-6 dB/Octave
2000 Hz Hz	0.026 g ² /Hz
Overall Overall	14.1 grms

NOTES:

1. Levels are for each of three orthogonal axes, one of which is normal to the mounting surface.
2. Levels to be applied at the interface with the EO-1 spacecraft.
3. Test duration is 1 minute per axis.
4. The levels may be reduced (notched) in specific frequency bands, with Project concurrence, if required to preclude damage resulting from unrealistic high amplification resonant response due to the shaker mechanical impedance and/or shaker/fixture resonance.
5. Flight-type attach hardware (including any thermal washers, etc.) shall be used to attach the test article to the test fixture, and preloads and fastener locking features shall be similar to the flight installation.
6. Cross-axis responses of the fixture shall be monitored during the test to preclude unrealistic levels.
7. During the test, the test article shall be operated in a mode representative of that during launch.

The following preliminary notched specifications (Table 12.2.2.2-2) have been calculated based on the Hyperion HSA finite element model (FEM) and provide the basis for notching the HSA vibration test spectrum. The actual notch used may need to be different to account for frequency shifts, mode shape changes, and damping changes, relative to the FEM. Project concurrence of the changes will be required for the final test specification.

Table 12.2.2.2-2a. Preliminary HSA Notched Acceptance Random Vibration Test Specification

X Direction		Y Direction		Z Direction	
Frequency (Hz)	Magnitude (g ² /Hz)	Frequency (Hz)	Magnitude (g ² /Hz)	Frequency (Hz)	Magnitude (g ² /Hz)
20	0.0065	20	0.0065	20	0.0065
50	0.04	50	0.04	50	0.04
80	0.04	60	0.04	110	0.04
100	0.000173	70	0.0003	130	0.0025
140	0.000173	90	0.0003	190	0.0025
160	0.04	100	0.04	210	0.00025
200	0.04	140	0.04	250	0.00025
210	0.0085	150	0.02	300	0.04
230	0.0085	170	0.02	500	0.04
240	0.04	180	0.04	2000	0.0064
500	0.04	500	0.04		
2000	0.0064	2000	0.0064		

Table 12.2.2.2-2b. Preliminary HSA STM Notched Protoflight Random Vibration Test Specification

X Direction		Y Direction		Z Direction	
Frequency (Hz)	Magnitude (g ² /Hz)	Frequency (Hz)	Magnitude (g ² /Hz)	Frequency (Hz)	Magnitude (g ² /Hz)
20	0.0129	20	0.0129	20	0.0129
50	0.08	50	0.08	50	0.08
80	0.08	60	0.08	110	0.08
100	0.00034	70	0.0006	130	0.005
140	0.00034	90	0.0006	190	0.005
160	0.08	100	0.08	210	0.0005
200	0.08	140	0.08	250	0.0005
210	0.017	150	0.04	300	0.08
230	0.017	170	0.04	500	0.08
240	0.08	180	0.08	2000	0.0127
500	0.08	500	0.08		
2000	0.0127	2000	0.0127		

12.2.3 Thermal Cycles Tests at Ambient

The ambient thermal cycle tests for the HEA and the CEA shall consist of one thermal cycle at the survival temperatures and one thermal cycle at the temperature limits per Table 12.2.1-2. The Hyperion instrument shall be operating during the thermal cycle at the operating temperatures. The Hyperion instrument survival and operating temperatures are listed in Tables 9.2.1-1 and 9.2.2-1.

12.2.4 Thermal Vacuum Tests

The thermal vacuum tests for the Hyperion instrument consists of one cycle at the survival temperatures, and seven thermal cycles at the temperature limits per Table 12.2.1-2. In addition, a thermal balance test and a vacuum performance verification test shall be conducted at the nominal (hot and cold) instrument operating temperatures.

12.2.5 EMI/EMC Testing

The Hyperion shall meet the electromagnetic compatibility requirements per AM-149-0020(155). The Hyperion instrument shall be tested per the procedures of MIL-STD-462 according to the requirement of MIL-STD-461C as amended by AM-149-0020(155).

The specific MIL-STD-461C test requirements are (1) Conducted Emissions including CE01, CE03, CE06, and CE07; (2) Conducted Susceptibility including CS01, CS02, CS03, CS04, CS05, and CS06; and (3) Radiated Emissions including RE01, RE02, and RE03. The Test Methods and Test Limits specifications are detailed in AM149-0020(155), p. 34.

12.2.6 Functional and Performance Testing

TRW will develop a functional test procedure to demonstrate all instrument functional requirements including processing of commands and telemetry over the 1773 interface and the collection and transmission of science data over the 32-wire RS-422 interface.

The instrument contractor shall develop a performance test procedure to measure the instrument performance requirements in the “Hyperion Instrument Specification,” EQ7-0459.

12.3 Hyperion Instrument Acceptance Test at GSFC

12.3.1 Instrument Acceptance Tests

Upon delivery of the Hyperion instrument to GSFC, the instrument contractor shall conduct a post-ship acceptance benchtest of the Hyperion at GSFC. GSFC shall provide a Class 100,000 or better clean room facility for the acceptance tests. Figure 12.3.1-1 shows the Hyperion instrument acceptance test configuration.

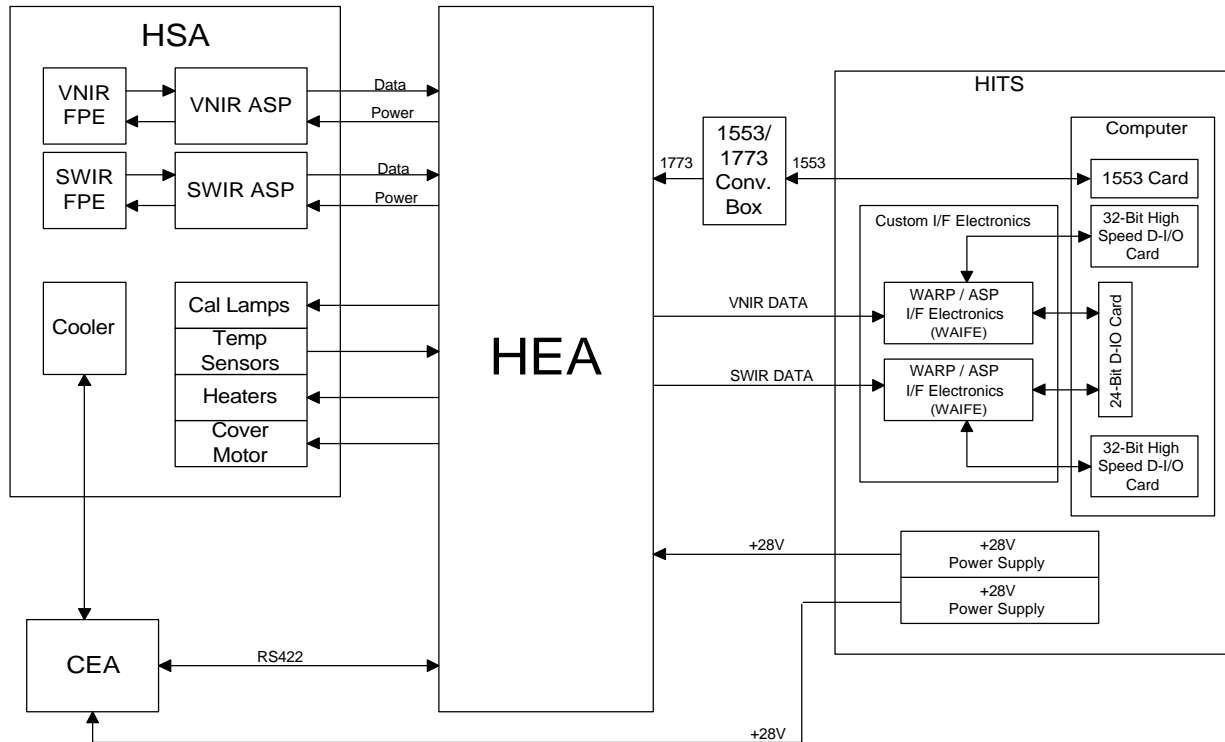


Figure 12.3.1-1. Hyperion Instrument Acceptance Test Configuration

12.3.2 Hyperion Instrument TestSet (HITS)

The instrument contractor shall provide a testset to support the above acceptance tests. This testset shall be capable of commanding the Hyperion, and shall be capable of collecting, displaying, and storing instrument telemetry and science data for verification of instrument functions and performance.

12.4 Post-Spacecraft Installation Hyperion Instrument Tests

12.4.1 Post-Spacecraft Installation Functional Test

After the installation of the Hyperion on the spacecraft, the Hyperion instrument functional test shall be the responsibility of GSFC. A conceptual Hyperion spacecraft integration and test configuration is shown in Figure 12.4.1-1. The instrument contractor shall provide the necessary procedures including 1773 commands for the functional tests, and the spacecraft contractor shall encode the 1773 commands into ASIST STOL. Instrument contractor support of the Hyperion spacecraft test at GSFC, including software and test data analysis support, is not planned and can be provided as an option.

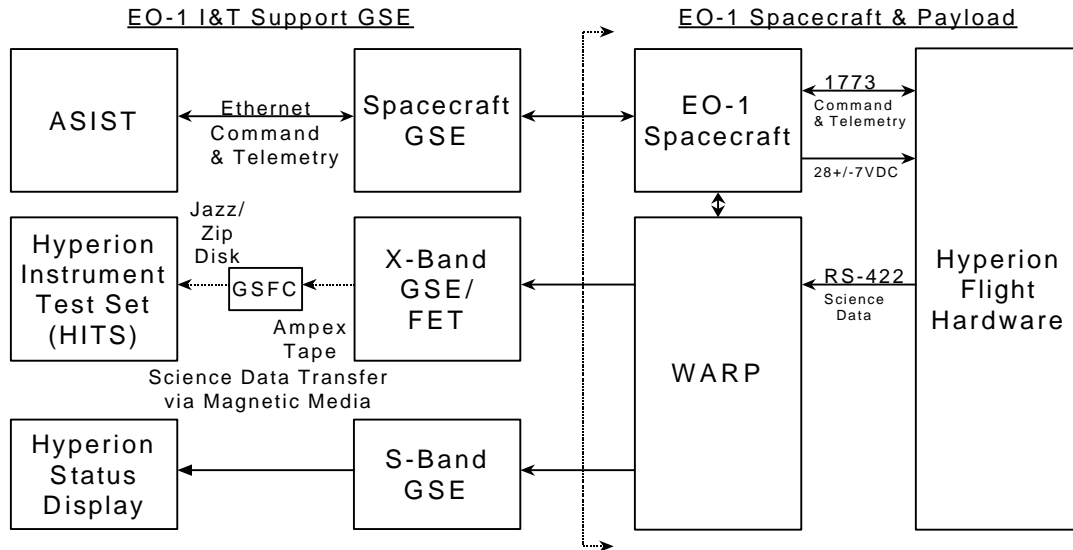


Figure 12.4.1-1. Hyperion Spacecraft Integration and Test Configuration

12.5 Operating Time

An operating time record of the Hyperion instrument shall be kept. The time record shall include the operating time for the aperture motor, the calibration lamps, the cryocooler pulse tube, and the electronics assemblies.

Section 13. Contamination and Cleanliness

13.1 As-Delivered Contamination Requirement

The Hyperion instrument will conform to a cleanliness level standard of 500A per MIL-STD-1246B. The instrument contamination control during integration shall conform to the “Hyperion Instrument Contamination Control Plan,” D27704.

13.2 Storage and Transportation Environment

The Hyperion instrument storage and transportation environment shall conform to the “Hyperion Instrument Contamination Control Plan,” D27704. The Hyperion assemblies shall be bagged, purged, and back-filled with filtered nitrogen gas (0.5 um filter) from an LN2 boil-off source at all times during storage and transportation. If filtered nitrogen gas from an LN2 boil-off source is not available, filtered, dry, 99.995%-pure semiconductor grade nitrogen with water content of <1 ppm can be substituted.

13.3 Integration and Test Facility Environment

The Hyperion integration and test facility environment shall conform to the “Hyperion Instrument Contamination Control Plan,” D27704. The Hyperion instrument shall remain bagged and purged with filtered nitrogen gas (0.5 um filter) from an LN2 boil-off source during integration on the spacecraft, except when it is necessary to make required electrical connections. The flow rate for the purge shall be 0.1 cu. ft. per hour nominal. If filtered nitrogen gas from an LN2 boil-off source is not available, filtered, dry, 99.995%-pure semiconductor grade nitrogen with water content of <1 ppm can be substituted.

Section 14. Spacecraft Integration and Launch Site Requirements

14.1 Hyperion Operating Constraints During Spacecraft Integration

The following constraints on Hyperion testing and operation shall be satisfied after its integration onto the spacecraft prior to on-orbit operation. Additional information and detail are in the "Hyperion Integration and Test Plan," D27446.

1. The Hyperion instrument aperture cover shall normally be closed during spacecraft integration. Aperture cover tests may be conducted inside the HSA protective bag if adequate clearance is established. Aperture cover open time must be minimized and logged. Any inadvertent opening of the aperture cover when the HSA is not bagged shall be reported immediately to the instrument contractor.
2. The SWIR focal plane shall not be cooled below 10°C at ambient pressure. This will curtail the operation of the SWIR FPA because it will not function properly at ambient temperature.
3. Operation of the in-flight calibration lamp sources in the HSA shall be monitored during I&T to prevent an over-temperature condition.
4. The HSA shall remain bagged at all times and shall be purged/backfilled with filtered nitrogen gas (0.5 um filter) from an LN2 boil-off source (or filtered, dry, 99.995%-pure semiconductor grade nitrogen with a water content of <1 ppm).
5. The number of calibration lamp cycles shall be minimized and logged. The cumulative calibration lamp operation time shall not exceed 10 minutes during satellite I&T.
6. The interior surface of the aperture cover shall not be touched to avoid damage to the sensitive calibration painted surface.

14.2 Integration and Test Facilities Contamination Level

The Hyperion-to-spacecraft integration shall take place in a Class 100,000 environment. A Class 10,000 tent or hood shall be used in the event the optical surface of the Hyperion instrument is exposed.

14.3 Ground Support Equipment

14.3.1 Mechanical Ground Support Equipment

The Hyperion HSA shall have lifting points per the interface control drawing A0765. The mechanical ground support equipment (MGSE) for the lifting and installation of the HSA shall be provided by the instrument contractor. The MGSE shall have a built-in 4.84-degree tilt to provide the proper orientation for the Hyperion during spacecraft installation. The HEA and the CEA can be handcarried and require no lift points.

14.3.2 Electrical Ground Support Equipment

With the exception of the HITS, all electrical ground support equipment (EGSE) shall be provided by GSFC to support Hyperion/spacecraft I&T per Figure 12.2.8.1-1. If GSFC elects to perform test procedure verification prior to Hyperion delivery, GSFC shall also provide test and characterization hardware for the 1773 interface, and an ASIST system.

14.4 Transportation, Handling, and Storage

The Hyperion instrument shall be protected during handling, transportation, storage, and other prelaunch activities per the “Hyperion Instrument Contamination Control Plan,” D27704.

14.4.1 Transportation Requirements

The Hyperion instrument shall be bagged and dry gas purged before transportation outside the controlled environment. The shipping container interior material and padding shall not generate particulate contamination and shall be cleaned prior to packing the Hyperion to MIL-STD-1246B, level 500, per the “Hyperion Instrument Contamination Control Plan,” D27704. All Hyperion assemblies shall remain bagged during transportation. The shipping container shall ~~be~~ have 20 g shock indicators instrumented to record maximum accelerations in all three axes ~~as specified (TBD)~~.

14.4.2 Handling Restrictions

The HSA handling fixture shall be used at all times, and the radiator surfaces shall not be touched during handling operations.

14.4.3 Storage Requirements

The Hyperion assemblies shall remain bagged during periods of storage. A dry nitrogen purge shall be provided during storage periods that are longer than 12 hours.

14.5 Satellite Environmental Tests

After delivery to GSFC, the Hyperion will be mounted to the satellite and undergo the following environmental tests as part of the completed satellite:

- Acoustic
- Shock
- Thermal balance
- Thermal vacuum

Complete details on these tests are contained in the Delta CDR presentations and in Revision D of the “EO-1 Integration and Test Plan,” SAI-PLAN-130.

14.6 Models for Satellite Environmental Test

TRW shall supply a structural thermal model of the HSA to be used during spacecraft vibration, thermal vacuum, and thermal balance tests.

14.7 Safety Documentation

The instrument contractor shall supply safety information to the spacecraft contractor. This includes all information required by the launch vehicle and launch site concerning the cryogenic pressurized component.

Section 15. Operational Requirements

15.1 Hyperion Instrument Operational Modes

Upon application of HEA and CEA power, the Hyperion instrument will boot up and enter idle mode. When HEA and CEA power is removed, Hyperion will be in off mode or survival mode, depending on whether the heater power is switched on.

15.1.1 Off Mode

In off mode, all internal power of the Hyperion, including the heaters, is off, and the aperture cover should have been secured. This mode will not be used on orbit.

When power is applied to the HEA, the unit shall self-boot and enter idle mode. When power is applied to the CEA, the unit shall also self-boot. After the CEA-processor is booted up, command and telemetry capabilities between the CEA and the HEA will be established.

15.1.2 Idle Mode

In idle mode, the instrument aperture cover is closed, the control processor is alive, heaters are operational, the cryocooler temperature is regulated, telemetry data shall be collected, and the 1773 interface shall be alive to support instrument/spacecraft command and telemetry.

15.1.3 Standby Mode

In standby mode, all components of the instrument are functional with the exception that no science data is transmitted to the spacecraft WARP.

15.1.4 Imaging Mode

In imaging mode, all components of the instrument are powered. The FPA data are clocked out to the ASPs, the data formatter, and transmitted to the spacecraft WARP. Collection of Earth imaging (science) data and solar calibration data are controlled by spacecraft pointing. Dark calibration or “zero” data is collected with the aperture closed. In-flight calibration data with the calibration lamp is taken with the aperture cover closed and the calibration lamp powered.

15.1.5 Survival Mode

In survival mode, the instrument aperture cover should have been closed, power is removed from the HEA and the CEA, and instrument command and telemetry capabilities are dropped. The HSA temperatures, including the cryocooler pulse tube, the VNIR FPA, and the SWIR FPA, are maintained by thermostat-controlled heaters.

15.1.6 Orbital Instrument Operation Sequence for Image Data

A typical data collection operation for the Hyperion instrument consists of the following steps:

Standby/warm-up	10 minutes
Dark calibration	1 second
Aperture open	15 seconds
Imaging mode	27 seconds
Aperture close	15 seconds
Dark calibration	1 second
Lamp calibration	45 seconds
Total	11 minutes and 44 seconds

15.2 Spacecraft Operation Constraints

The Hyperion instrument imposes the following constraints on the spacecraft operational modes:

1. Survival heater power shall be continuously provided to the Hyperion, including during launch.
2. The instrument survival mode shall be used only in anomalous conditions.
3. The cryocooler flange shall be kept above -10°C for startup and during operation.
4. When the Hyperion instrument aperture cover is opened, operators shall restrict the Sun position per drawing A0765 to avoid damage to the FPAs.
5. After launch, the Hyperion will remain in the survival mode for 1 to 2 weeks, until the operations team completes initial checkout of the spacecraft systems.

Additional and all instrument operation constraints shall be included in the Hyperion Flight Operation Handbook.

15.3 Health and Safety

The spacecraft shall monitor several critical telemetry parameters and take appropriate action if the values exceed predetermined limits. TRW shall work with Swales Aerospace to specify the telemetry points, the limits, and the designated actions. Details of the telemetry points, limits, and actions shall be included in the Hyperion Flight Operation Handbook and SAI-STD-056.

The Hyperion instrument shall monitor various spacecraft parameters and take action if spacecraft anomaly is detected. Details of the parameters monitored by the Hyperion shall be included in the Hyperion Flight Operation Handbook.

Appendix A. Hyperion Connector Specifications and Pin Assignments

A.1 Hyperion 28 VDC Power Connector and Pin Assignments

A.1.1 28 VDC Power Connector Specification

The Hyperion HEA shall have one 28 VDC power connector and the connector shall be a 9-pin pin-type D-connector. The Hyperion CEA shall have one 28 VDC power connector and the connector shall be a 9-pin pin-type D-connector.

A.1.2 HEA 28 VDC Connector Pin Assignments

The HEA 28 VDC connector pin assignments shall be as specified in Table A.1.2-1.

Table A.1.2-1. HEA J101, 2A014-111V-001(9P), Connector Pin Assignments

Pin #	Signal Name	Description
1	+28V	+28V Bus
2	+28V	+28V Bus
3	+28VH	+28V Heater Bus
4	+28VH	+28V Heater Bus
5	CGND	Chasis ground
6	28V RTN	+28V Bus Return
7	28V RTN	+28V Bus Return
8	28VH RTN	+28V Heater Bus Return
9	28VH RTN	+28V Heater Bus Return

A.1.3 CEA 28 VDC Connector Pin Assignments

The CEA 28 VDC connector pin assignments shall be as specified in Table A.1.3-1. The CEA 28 VDC power lines shall be common with the HEA 28 VDC power lines.

A.1.4 HSA Temperature Monitor Connector Pin Assignment

The HSA shall have four temperature sensors (YSI 44905 thermistors, GSFC S311P18-05A76R, 5K Ohms at 25°C) routed to a 9-pin D-connector for monitoring by the spacecraft. The pin assignments for the connector is shown in Table A.1.4-1.

Table A.1.3-1. CEA J101, M24308/4-1(9P), Connector Pin Assignments

Pin #	Signal Name	Description
1	CHGND	Chassis ground
2	<u>28V RTNPWRA+</u>	<u>+28V A-Bus (Common with HEA J101-1,2) 28V Bus Return (Common with HEA J101-6,7)</u>
3	<u>28V RTNPWRA+</u>	<u>+28V Bus Return (Common with HEA J101-6,7) +28V A-Bus (Common with HEA J101-1,2)</u>
4	<u>28V RTNPWRB-</u>	<u>+28V Bus Return (Common with HEA J101-6,7)</u>
5	<u>28V RTN PWRB-</u>	<u>+28V Bus Return (Common with HEA J101-6,7)</u>
6	<u>+28V PWRB+</u>	<u>+28V S/C Bus (Common with HEA J101-1,2)</u>
7	<u>+28V PWRB+</u>	<u>+28V S/C Bus (Common with HEA J101-1,2)</u>
8	<u>+28V PWRA-</u>	<u>+28V S/C Bus (Common with HEA J101-1,2) +28V A-Bus Return (Common with HEA J101-6,7)</u>
9	<u>+28V PWRA-</u>	<u>+28V S/C Bus (Common with HEA J101-1,2) +28V A-Bus Return (Common with HEA J101-6,7)</u>

Table A.1.4-1. HSA Temperature Monitor J210, 2A014-041V-001(9P), Connector Pin Assignments

Pin #	Signal Name	Description
1	TEMP_1+	OMS temperature
2	TEMP_2+	Cryocooler flange temperature
3	TEMP_3+	VNIR ASP temperature
4	TEMP_4+	SWIR ASP temperature
5	GND	
6	TEMP_1-	OMS temperature return
7	TEMP_2-	Cryocooler flange temperature return
8	TEMP_3-	VNIR ASP temperature return
9	TEMP_4-	SWIR ASP temperature return

A.2 32-Wire RS-422 Interface Connector Specification and Pin Assignments

A.2.1 32-Wire RS-422 Interface Connector Specification

The Hyperion VNIR and SWIR 32-wire RS-422 science data bus shall use a 78-pin socket-type D-connector.

A.2.2 32-Wire RS-422 Interface Connector Pin Assignments

The connector pin assignments for the SWIR and the VNIR image data shall be as specified in Tables A.2.2-1 and A.2.2-2, respectively.

Table A.2.2-1. VNIR Image Data 32-Wire RS-422 Interface Connector J110, 2A065-023V-001(78S), Connector Pin Assignments (1 of 2)

Pin #	Signal Name	Description	
1	WVDATA00H	Data bit 0 - positive	TP #0
20	NC	No connect	
21	WVDATA00L	Data bit 0 - negative	TP #0
2	WVDATA01H	Data bit 1 - positive	TP #1
22	WVDATA01L	Data bit 1 - negative	TP #1
3	WVDATA02H	Data bit 2 - positive	TP #2
23	WVDATA02L	Data bit 2 - negative	TP #2
4	WVDATA03H	Data bit 3 - positive	TP #3
24	WVDATA03L	Data bit 3 - negative	TP #3
5	WVDATA04H	Data bit 4 - positive	TP #4
25	WVDATA04L	Data bit 4 - negative	TP #4
6	WVDATA05H	Data bit 5 - positive	TP #5
26	WVDATA05L	Data bit 5 - negative	TP #5
7	WVDATA06H	Data bit 6 - positive	TP #6
27	WVDATA06L	Data bit 6 - negative	TP #6
8	WVDATA07H	Data bit 7 - positive	TP #7
28	WVDATA07L	Data bit 7 - negative	TP #7
9	WVDATA08H	Data bit 8 - positive	TP #8
29	WVDATA08L	Data bit 8 - negative	TP #8
10	WVDATA09H	Data bit 9 - positive	TP #9
30	WVDATA09L	Data bit 9 - negative	TP #9
11	WVDATA10H	Data bit 10 - positive	TP #10
31	WVDATA10L	Data bit 10 - negative	TP #10
12	WVDATA11H	Data bit 11 - positive	TP #11
32	WVDATA11L	Data bit 11 - negative	TP #11
13	WVDATA12H	Data bit 12 - positive	TP #12
33	WVDATA12L	Data bit 12 - negative	TP #12
14	WVDATA13H	Data bit 13 - positive	TP #13
34	WVDATA13L	Data bit 13 - negative	TP #13
15	WVDATA14H	Data bit 14 - positive	TP #14
35	WVDATA14L	Data bit 14 - negative	TP #14
16	WVDATA15H	Data bit 15 - positive	TP #15
36	WVDATA15L	Data bit 15 - negative	TP #15
17	WVDATA16H	Data bit 16 - positive	TP #16
37	WVDATA16L	Data bit 16 - negative	TP #16
18	WVDATA17H	Data bit 17 - positive	TP #17
38	WVDATA17L	Data bit 17 - negative	TP #17
19	WVDATA18H	Data bit 18 - positive	TP #18
39	WVDATA18L	Data bit 18 - negative	TP #18
40	NC	No connect	

Table A.2.2-1. VNIR Image Data 32-Wire RS-422 Interface Connector J110, 2A065-023V-001(78S), Connector Pin Assignments (2 of 2)

Pin #	Signal Name	Description	
41	NC	No connect	
42	N/A	Clk Shield	Shield for TP #32
43	NC	No connect	
44	NC	No connect	
45	WVDATA19H	Data bit 19 - positive	TP #19
65	WVDATA19L	Data bit 19 - negative	TP #19
46	WVDATA20H	Data bit 20 - positive	TP #20
66	WVDATA20L	Data bit 20 - negative	TP #20
47	WVDATA21H	Data bit 21 - positive	TP #21
67	WVDATA21L	Data bit 21 - negative	TP #21
48	WVDATA22H	Data bit 22 - positive	TP #22
68	WVDATA22L	Data bit 22 - negative	TP #22
49	WVDATA23H	Data bit 23 - positive	TP #23
69	WVDATA23L	Data bit 23 - negative	TP #23
50	WVDATA24H	Data bit 24 - positive	TP #24
70	WVDATA24L	Data bit 24 - negative	TP #24
51	WVDATA25H	Data bit 25 - positive	TP #25
71	WVDATA25L	Data bit 25 - negative	TP #25
52	WVDATA26H	Data bit 26 - positive	TP #26
72	WVDATA26L	Data bit 26 - negative	TP #26
53	WVDATA27H	Data bit 27 - positive	TP #27
73	WVDATA27L	Data bit 27 - negative	TP #27
54	WVDATA28H	Data bit 28 - positive	TP #28
74	WVDATA28L	Data bit 28 - negative	TP #28
55	WVDATA29H	Data bit 29 - positive	TP #29
75	WVDATA29L	Data bit 29 - negative	TP #29
56	WVDATA30H	Data bit 30 - positive	TP #30
76	WVDATA30L	Data bit 30 - negative	TP #30
57	WVDATA31H	Data bit 31 - positive	TP #31
58	NC	No connect	
59	NC	No connect	
60	NC	No connect	
63	NC	No connect	
64	NC	No connect	
77	WVDATA31L	Data bit 31 - negative	TP #31
78	NC	No connect	
61	WVCLKH	Port Clock - positive	TP #32
62	WVCLKL	Port Clock - negative	TP #32

Table A.2.2-2 SWIR Image Data 32-Wire RS-422 Interface Connector J111, 2A065-017V-001(78P), Connector Pin Assignments (1 of 2)

Pin #	Signal Name	Description	
1	WSDAT00H	Data bit 0 - positive	TP #0
20	NC	No connect	
21	WSDATA00L	Data bit 0 - negative	TP #0
2	WSDATA01H	Data bit 1 - positive	TP #1
22	WSDATA01L	Data bit 1 - negative	TP #1
3	WSDATA02H	Data bit 2 - positive	TP #2
23	WSDATA02L	Data bit 2 - negative	TP #2
4	WSDATA03H	Data bit 3 - positive	TP #3
24	WSDATA03L	Data bit 3 - negative	TP #3
5	WSDATA04H	Data bit 4 - positive	TP #4
25	WSDATA04L	Data bit 4 - negative	TP #4
6	WSDATA05H	Data bit 5 - positive	TP #5
26	WSDATA05L	Data bit 5 - negative	TP #5
7	WSDATA06H	Data bit 6 - positive	TP #6
27	WSDATA06L	Data bit 6 - negative	TP #6
8	WSDATA07H	Data bit 7 - positive	TP #7
28	WSDATA07L	Data bit 7 - negative	TP #7
9	WSDATA08H	Data bit 8 - positive	TP #8
29	WSDATA08L	Data bit 8 - negative	TP #8
10	WSDATA09H	Data bit 9 - positive	TP #9
30	WSDATA09L	Data bit 9 - negative	TP #9
11	WSDATA10H	Data bit 10 - positive	TP #10
31	WSDATA10L	Data bit 10 - negative	TP #10
12	WSDATA11H	Data bit 11 - positive	TP #11
32	WSDATA11L	Data bit 11 - negative	TP #11
13	WSDATA12H	Data bit 12 - positive	TP #12
33	WSDATA12L	Data bit 12 - negative	TP #12
14	WSDATA13H	Data bit 13 - positive	TP #13
34	WSDATA13L	Data bit 13 - negative	TP #13
15	WSDATA14H	Data bit 14 - positive	TP #14
35	WSDATA14L	Data bit 14 - negative	TP #14
16	WSDATA15H	Data bit 15 - positive	TP #15
36	WSDATA15L	Data bit 15 - negative	TP #15
17	WSDATA16H	Data bit 16 - positive	TP #16
37	WSDATA16L	Data bit 16 - negative	TP #16
18	WSDATA17H	Data bit 17 - positive	TP #17
38	WSDATA17L	Data bit 17 - negative	TP #17
19	WSDATA18H	Data bit 18 - positive	TP #18
39	WSDATA18L	Data bit 18 - negative	TP #18
40	NC	No connect	

Table A.2.2-2 SWIR Image Data 32-Wire RS-422 Interface Connector J111, 2A065-017V-001(78P), Connector Pin Assignments (2 of 2)

Pin #	Signal Name	Description	
41	NC	No connect	
42	N/A	Clk Shield	Shield for TP #32
43	NC	No connect	
44	NC	No connect	
45	WSDATA19H	Data bit 19 - positive	TP #19
65	WSDATA19L	Data bit 19 - negative	TP #19
46	WSDATA20H	Data bit 20 - positive	TP #20
66	WSDATA20L	Data bit 20 - negative	TP #20
47	WSDATA21H	Data bit 21 - positive	TP #21
67	WSDATA21L	Data bit 21 - negative	TP #21
48	WSDATA22H	Data bit 22 - positive	TP #22
68	WSDATA22L	Data bit 22 - negative	TP #22
49	WSDATA23H	Data bit 23 - positive	TP #23
69	WSDATA23L	Data bit 23 - negative	TP #23
50	WSDATA24H	Data bit 24 - positive	TP #24
70	WSDATA24L	Data bit 24 - negative	TP #24
51	WSDATA25H	Data bit 25 - positive	TP #25
71	WSDATA25L	Data bit 25 - negative	TP #25
52	WSDATA26H	Data bit 26 - positive	TP #26
72	WSDATA26L	Data bit 26 - negative	TP #26
53	WSDATA27H	Data bit 27 - positive	TP #27
73	WSDATA27L	Data bit 27 - negative	TP #27
54	WSDATA28H	Data bit 28 - positive	TP #28
74	WSDATA28L	Data bit 28 - negative	TP #28
55	WSDATA29H	Data bit 29 - positive	TP #29
75	WSDATA29L	Data bit 29 - negative	TP #29
56	WSDATA30H	Data bit 30 - positive	TP #30
76	WSDATA30L	Data bit 30 - negative	TP #30
57	WSDATA31H	Data bit 31 - positive	TP #31
58	NC	No connect	
59	NC	No connect	
60	NC	No connect	
63	NC	No connect	
64	NC	No connect	
77	WSDATA31L	Data bit 31 - negative	TP #31
78	NC	No connect	
61	WSCLKH	Port Clock - positive	TP #32
62	WSCLKL	Port Clock - negative	TP #32

A.3 1773 Instrument Command and Telemetry Interface Connector Specification

The Hyperion 1773 command and telemetry interface shall consist of a primary “A” and a redundant “B” circuit. Each circuit shall have a transmission and a receiving fiber optics connection. All 1773 interface fiber optics connectors shall be of the type R2525-4 (Johanson). The detailed fiber optics connector definition is shown in Figure 3.4-1.

Appendix B-1. Hyperion Command and Telemetry

B 1.1 Command Packet Header Command Packet Header

Most Significant Bits														Least Significant Bits			
Description	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Packet header 1	Version Number			Type	Sec. Header	Application Process ID											
Packet header 2	Segment Flags		Source Sequence Count														
Packet header 3	Packet Length																
Secondary Header	Reserv e	Function Code								Exclusive OR Checksum							

Time Code Distribution

“Tone message:”

Broadcast Subaddress 29

Most Significant Bits														Least Significant Bits			
Description	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Packet header 1	Version Number			Type	Sec. Header	Application Process ID											
Packet header 2	Segment Flags		Source Sequence Count														
Packet header 3	Packet Length																
Secondary Header	Reserv e	Function Code								Exclusive OR Checksum							

“At the tone the time was:”

Broadcast Subaddress 28

Most Significant Bits														Least Significant Bits			
Description	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
Packet header 1	Version Number			Type	Sec. Header	Application Process ID											
Packet header 2	Segment Flags		Source Sequence Count														
Packet header 3	Packet Length																
Secondary Header	Reserv e	Function Code								Exclusive OR Checksum							
Data Word 1	Sequence Counter																

EO-1ICD-65
Baseline Issue
March 22, 1999

Data Word 2	Time code: Most Significant Word
Data Word 3	
Data Word 4	
Data Word 5	Time code: Least Significant Word

Wrap Around Data

Transmit Subaddress 30

B.2 Instrument Command List

		MSB				LSB			
Mnemonic	Command	15	12	1	8	7	4	3	0
1NOOP	No operation	0		0		0		0	
1NVPAR	Set VNIR Params	0		1		0		2	
				0				VNIR Offset A	
				0				VNIR Offset B	
				0				VNIR Offset C	
				0				VNIR Offset D	
1SWPAR	Set SWIR Params	0		1		0		3	
				0				Gain A	
				0				Gain B	
				0				Gain C	
				0				Gain D	
		0						Offset A	
		0						Offset B	
		0						Offset C	
		0						Offset D	
		0						Integration Time	
1OPCVR	Cover Open	0		2		0		1	
1CLCVR	Cover Close	0		2		0		2	
1SCCVR	Cover to Solar Cal	0		2		0		3	
1CL1LV	Set Prim. Lamp Level	0		3		0		1	
				0				Primary Lamp Level (0-255)	
1CL2LV	Set Sec. Lamp Level	0		3		0		2	
				0				Secondary Lamp Level (0-255)	
1STHTR	Set Heater Setpoints	0		4		0		1	
		0						Heater 1 Minimum Temp	
		0						Heater 1 Maximum Temp	
		0						Heater 2 Minimum Temp	
		0						Heater 2 Maximum Temp	
		0						Heater 3 Minimum Temp	
		0						Heater 3 Maximum Temp	
		0						Heater 4 Minimum Temp	
		0						Heater 4 Maximum Temp	
		0						Heater 5 Minimum Temp	
		0						Heater 5 Maximum Temp	
		0						Heater 6 Minimum Temp	
		0						Heater 6 Maximum Temp	
		0						Heater 7 Minimum Temp	
		0						Heater 7 Maximum Temp	

		0	Heater 8 Minimum Temp		
		0	Heater 8 Maximum Temp		
1SRTAQ	Start Data Acquisition	0	5	0	1
1STPAQ	Stop Data Acquisition	0	5	0	2
1RESET	Hyperion Reset	0	6	0	1
1GOIDL	Go to Idle Mode	0	6	0	2
1GOSBY	Go to Standby Mode	0	6	0	3
1SFHLD	Go to Safe Hold Mode	0	6	0	4
1POKBT	Poke 8-bit	0	7	0	1
			Offset		
			Segment		
			Data		
1POKWD	Poke 16-bit	0	7	0	2
			Offset		
			Segment		
			Data		
1POKLG	Poke 32-bit	0	7	0	3
			Offset		
			Segment		
			Data (low)		
			Data (high)		
1PKDAT	Peek	0	7	0	4
			Offset		
			Segment		
1CRTON	Start Cryo Telem Acq	0	8	0	1
1CRTOF	Stop Cryo Telem Acq	0	8	0	2

EO-1ICD-65
Baseline Issue
March 22, 1999

B 6.3 Telemetry Packet

Most Significant Bits															Least Significant Bits	
Description	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Semaphore	Semaphore (zero or unchanged means no new packet)															
Packet header 1	Version Number			Type	Sec. Header	Application Process ID										
Packet header 2	Segment Flags		Source Sequence Count													
Packet header 3	Packet Length															
Secondary Hdr1	Time code: Most Significant Word															
Secondary Hdr2																
Secondary Hdr3																
Secondary Hdr4	Time code: Least Significant Word															
Status	Spare	Collect Cryo telem 1 = on	Cover Status 0 = closed 1 = calibrate 2 = open	Data Collect	Standby	Watch-Dog Reset	SC Reset	Heater7 1 = On	Heater6 1 = On	Heater5 1 = On	Heater4 1 = On	Heater3 1 = On	Heater2 1 = On	Heater1 1 = On	Heater0 1 = On	
Heater 0 Min	Not Used			+ X Panel Heater Minimum temperature setpoint												
Heater 0 Max	Not Used			+ X Panel Heater Maximum temperature setpoint												
Heater 1 Min	Not Used			+Y Panel Heater Minimum temperature setpoint												
Heater 1 Max	Not Used			+Y Panel Heater Maximum temperature setpoint												
Heater 2 Min	Not Used			-X & -Y Panel Heater Minimum temperature setpoint												
Heater 2 Max	Not Used			-X & -Y Panel Heater Maximum temperature setpoint												
Heater 3 Min	Not Used			Top Panel Heater Minimum temperature setpoint												
Heater 3 Max	Not Used			Top Panel Heater Maximum temperature setpoint												
Heater 4 Min	Not Used			Botton Panel Heater Minimum temperature setpoint												
Heater 4 Max	Not Used			Botton Panel Heater Maximum temperature setpoint												
Heater 5 Min	Not Used			VNIR ASP Heater Minimum temperature setpoint												
Heater 5 Max	Not Used			VNIR ASP Heater Maximum temperature setpoint												
Heater 6 Min	Not Used			SWIR ASP Heater Minimum temperature setpoint												
Heater 6 Max	Not Used			SWIR ASP Heater Maximum temperature setpoint												
Heater 7 Min	Not Used			Heater 7 Minimum temperature setpoint												
Heater 7 Max	Not Used			Heater 7 Maximum temperature setpoint												
Cal Lamp 1 Value				In-Flight Calibration Lamp 1 Commanded Value												
Cal Lamp 2 Value				In-Flight Calibration Lamp 2 Commanded Value												
Cal Lamp 1 Current	Not Used			In-Flight Calibration Lamp 1 Current												
Cal Lamp 2 Current	Not Used			In-Flight Calibration Lamp 2 Current												
Cal Lamp 1 Voltage	Not Used			In-Flight Calibration Lamp 1 Voltage												

EO-1ICD-65
Baseline Issue
March 22, 1999

Cal Lamp 2 Voltage	Not Used	In-Flight Calibration Lamp 2 Voltage			
HSA Temp1	Not Used	+ X Panel Temperature			
HSA Temp2	Not Used	+Y Panel Temperature			
HSA Temp3	Not Used	-X & -Y Panel Temperature			
HSA Temp4	Not Used	Top Panel Temperature			
HSA Temp5	Not Used	Bottom Panel Temperature			
HSA Temp6	Not Used	VNIR FPE Temperature			
HSA Temp7	Not Used	VNIR ASP Temperature			
HSA Temp8	Not Used	SWIR ASP Temperature			
Spare Temp	Not Used	Spare Temperature			
Spare Temp	Not Used	Spare Temperature			
Spare Temp	Not Used	Spare Temperature			
OMS Temp	Not Used	OMS Temperature			
Baffle Temp	Not Used	Baffle Temperature			
Cooler Temp	Not Used	Cooler Temperature			
VNIR FPGA Temp	Not Used	VNIR FPGA Temperature			
HPE Temp	Not Used	HPE Temperature			
HEA +5V	Not Used	HEA +5V			
HEA +15V	Not Used	HEA +15V			
HEA -15V	Not Used	HEA -15V			
VNIR +5VD	Not Used	VNIR +5VD			
VNIR +5VA	Not Used	VNIR +5VA			
VNIR -5VA	Not Used	VNIR -5VA			
VNIR +15VA	Not Used	VNIR +15VA			
VNIR -15VA	Not Used	VNIR -15VA			
SWIR +5VD	Not Used	SWIR +5VD			
SWIR +5VA	Not Used	SWIR +5VA			
SWIR -5VA	Not Used	SWIR -5VA			
SWIR +15V	Not Used	SWIR +15V			
SWIR -15V	Not Used	SWIR -15V			
Cover Position	Not Used	Cover Position			
Spare Analog Telem	Not Used	Spare Analog Telemetry			
Spare Analog Telem	Not Used	Spare Analog Telemetry			
SWIR Param 1	SWIR Offset B (Range 0 to 255)		SWIR Offset A (Range 0 to 255)		
SWIR Param 2	SWIR Offset D (Range 0 to 255)		SWIR Offset C (Range 0 to 255)		
SWIR Param 3	SWIR Integration Time		SWIR Gain D (0-3)	SWIR Gain C (0-3)	SWIR Gain B (0-3) SWIR Gain A (0-3)
VNIR Parameters	VNIR Offset D (Range 0 to 15)	VNIR Offset C (Range 0 to 15)	VNIR Offset B (Range 0 to 15)		VNIR Offset A (Range 0 to 15)

EO-1ICD-65
Baseline Issue
March 22, 1999

Peek Offset	Offset Address from peek command	
Peek Segment	Segment Address from peek command	
Peek Data Low	Least significant word of peek data	
Peek Data High	Most significant word of peek data	
Counters	Error counter	Command counter
Command Buffer 0	Most recently received command opcode	
Command Buffer 1		
Command Buffer 2		
Command Buffer 3	Fifth most recently received command opcode	
Error Buffer 0	Most recently recorded error condition	
Error Buffer 1	Second most recently recorded error condition	
Cryocooler Telem Semaphore	Cryocooler telemetry semaphore (zero or unchanged means no new cryocooler telemetry packet)	
Cryocooler Telem 0	0xEB90	
Cryocooler Telem 1	0x0430	
Cryocooler Telem 2	0x1002	
Cryocooler Telem 3	Header Checksum	
Cryocooler Telem 4	Most significant word of timer	
Cryocooler Telem 5	Least significant word of timer	
Cryocooler Telem 6	Cold head temperature	
Cryocooler Telem 7	Electronics temperature 2	
Cryocooler Telem 8	Center plate temperature	
Cryocooler Telem 9	+ Peak drive, side 1	
Cryocooler Telem 10	- Peak drive, side 1	
Cryocooler Telem 11	+ Peak drive, side 2	
Cryocooler Telem 12	- Peak drive, side2	
Cryocooler Telem 13	Status Word 0	
Cryocooler Telem 14	Status Word 1	
Cryocooler Telem 15	Status Word 2	
Cryocooler Telem 16	Electronics temperature 1	
Cryocooler Telem 17	DC offset side 1	
Cryocooler Telem 18	DC offset side 2	
Cryocooler Telem 19	Average peak input current	
Cryocooler Telem 20	Average Current side 1	
Cryocooler Telem 21	Average Current side 2	
Cryocooler Telem 22	5V supply	
Cryocooler Telem 23	+12V supply	
Cryocooler Telem 24	-12V supply	

EO-1ICD-65
Baseline Issue
March 22, 1999

Cryocooler Telem 25	+60V supply
Cryocooler Telem 26	-60V supply
Cryocooler Telem 27	10 Log10(RSS of all harmonics)
Cryocooler Telem 28	Vibration level 1
Cryocooler Telem 29	Vibration level 2
Cryocooler Telem 30	Vibration level 3
Cryocooler Telem 31	Vibration level 4
Cryocooler Telem 32	Vibration level 5
Cryocooler Telem 33	Vibration level 6
Cryocooler Telem 34	Vibration level 7
Cryocooler Telem 35	Vibration level 8
Cryocooler Telem 36	Vibration level 9
Cryocooler Telem 37	Vibration level 10
Cryocooler Telem 38	Vibration level 11
Cryocooler Telem 39	Vibration level 12
Cryocooler Telem 40	Vibration level 13
Cryocooler Telem 41	Vibration level 14
Cryocooler Telem 42	Vibration level 15
Cryocooler Telem 43	Vibration level 16
Cryocooler Telem 44	Xloops
Cryocooler Telem 45	Vloops
Cryocooler Telem 46	Motor drive
Cryocooler Telem 47	Packet Checksum (Telemetry packet only)

B.4 Hyperion Cryocooler Command Packet

Cryocooler Command Packet	# of Words
Header	4
Command	Up to 572

B.5 Hyperion Cryocooler Command List

The complete Hyperion cryocooler command list is documented in ~~D26977~~[D27802](#), [Hyperion MPT Cryocooler TES-FPC](#) Control Software: Architecture and Software User's Manual, pp. ~~232-1~~[5482](#).

B.6 Hyperion Cryocooler Telemetry Packet

Cryocooler Telemetry Packet	# of Words
Semaphore	1
Header	7
Data	Up to 504

B.7 Hyperion Cryocooler Telemetry List

The complete Hyperion cryocooler telemetry list is documented in D2~~78026977~~[78026977](#), [Hyperion MPT Cryocooler TES-FPC](#) Control Software: Architecture and Software User's Manual, pp. ~~1585-176205~~[176205](#).

Appendix C. 32-Wire RS-422 Image Data Format

C.1 Hyperion Image Data Format

C.1.1 Hyperion VNIR Image Data Format

Count N	Hyperion VNIR Data Format					
	MSB DB(31:24)	DB(23:18)	DB(15:8)		DB(7:0) LSB	
1	VNIR Header ID	TC8	TC7		TC6	
2	VNIR Header ID	TC5	TC4		TC3	
3	VNIR Header ID	XX	OSD	OSC	OSB	OSA
4	VNIR Header ID	Sync Time	Frame #			
	DB(31:28)	MSB DB(27:16) LSB	DB(15:12)	MSB DB(11:0) LSB		
5	VNIR ID	VNIR Data Word 1	VNIR ID	VNIR Data Word 2		
6	VNIR ID	VNIR Data Word 3	VNIR ID	VNIR Data Word 4		
----	----	----	----	----		
----	----	----	----	----		
8963	VNIR ID	VNIR Data Word 17917	VNIR ID	VNIR Data Word 17918		
8964	VNIR ID	VNIR Data Word 17919	VNIR ID	VNIR Data Word 17920		

NOTE: "VNIR Header ID" is "FE" and "VNIR ID" is "1".

C.1.2 Hyperion SWIR Image Data Format

Count N	Hyperion SWIR Data Format									
	MSB DB(31:24)		DB(23:18)				DB(15:8)		DB(7:0) LSB	
1	SWIR Header ID		TC8				TC7		TC6	
2	SWIR Header ID		TC5				TC4		TC3	
3	SWIR Header ID		INT Time				OSD		OSC	
4	SWIR Header ID		GD	GC	GB	GA	OSB		OSA	
5	SWIR Header ID		Sync Time				Frame #			
	DB(31:28)		MSB DB(27:16) LSB				DB(15:12)		MSB DB(11:0) LSB	
6	SWIR ID		SWIR Data Word 1				SWIR ID		SWIR Data Word 2	
7	SWIR ID		SWIR Data Word 3				SWIR ID		SWIR Data Word 4	
-----	-----		-----				-----		-----	
-----	-----		-----				-----		-----	
22020	SWIR ID		SWIR Data Word 44029				SWIR ID		SWIR Data Word 44030	
22021	SWIR ID		SWIR Data Word 44031				SWIR ID		SWIR Data Word 44032	

NOTE: "SWIR Header ID" is "FA" and "SWIR ID" is "2".

C.1.3 Time Code Definition

Spacecraft Time Code							
Seconds				Sub-seconds			
TC8	TC7	TC6	TC5	TC4	TC3	TC2	TC1
Time Code Used in Hyperion Image Data Header							

Abbreviations and Acronyms

°C	degree Celsius
μrad	microradian
AC	alternating current
ACDS	
ALI	Advanced Land Imager
arcsec	arc second
ASP	analog signal processing
BC	bus controller
CCB	Configuration Control Board
CCSDS	Consultative Committee for Space Data Systems
CEA	Cryocooler Electronics Assembly
cm	centimeter
DC	direct current
EGSE	electrical ground support equipment
EO-1	Earth Orbiter-1
FDS	Flight Data System
FEM	finite element model
FOV	field of view
FPA	focal plane array
FPE	focal plane electronics
FPM	FPE module
GIS	Grating Imaging Spectrometer
GPS	Global Positioning System
GSD	ground sample distance
GSFC	Goddard Space Flight Center
HEA	Hyperion Electronics Assembly
HITS	Hyperion Instrument TestSet
HSA	Hyperion Sensor Assembly

Hz	hertz
I&T	integration and test
ICD	interface control document
IFCS	in-flight calibration source
in.	inch
kg	kilogram
kg-cm ²	
kHz	kilohertz
km	kilometer
km/sec	km/sec
LSB	least significant bit
m	meter
MGSE	mechanical ground support equipment
MLI	multilayer insulation
MSB	most significant bit
N	
nm	
OMS	Opto-Mechanical Subsystem
pf	
ppm	parts per minute
ROM	
RT	remote terminal
SWIR	shortwave infrared
TBD	to be determined
TMA	Three Mirror Astigmat
um	
V	volt
VDC	volt direct current
VNIR	visible and near infrared

W	watt
WARP	Wideband Advanced Recorder/Processor

Command Packet Header

Most Significant Bits											Least Significant Bits					
Description	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Packet header 1	Version Number			Type	Sec. Header	Application Process ID										
Packet header 2	Segment Flags		Source Sequence Count													
Packet header 3	Packet Length															
Secondary Header	Reserve	Function Code							Exclusive OR Checksum							

Time Code Distribution

“Tone message:”

Broadcast Subaddress 29

Most Significant Bits											Least Significant Bits					
Description	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Packet header 1	Version Number			Type	Sec. Header	Application Process ID										
Packet header 2	Segment Flags		Source Sequence Count													
Packet header 3	Packet Length															
Secondary Header	Reserve	Function Code							Exclusive OR Checksum							

"At the tone the time was:"
Broadcast Subaddress 28

Most Significant Bits											Least Significant Bits					
Description	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Packet header 1	Version Number			Type	Sec. Header	Application Process ID										
Packet header 2	Segment Flags		Source Sequence Count													
Packet header 3	Packet Length															
Secondary Header	Reserve	Function Code								Exclusive OR Checksum						
Data Word 1	Sequence Counter															
Data Word 2	Time code: Most Significant Word															
Data Word 3																
Data Word 4																
Data Word 5	Time code: Least Significant Word															

Wrap Around Data

Transmit Subaddress 30

